CONTRACT NAS9-9953
DRL NO: MSC T-575, LINE ITEM 61
MSC-02465

SD 71-211

15-FOOT-DIAMETER MODULAR space station PHASE B EXTENSION

KSC LAUNCH SITE SUPPORT DEFINITION

PREPARED BY PROGRAM ENGINEERING
23 November 1971

Space Division
North American Rockwell
12214 Lakewood Boulevard, Downey, California 90241

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APPROVED BY

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TECHNICAL REPORT INDEX/ABSTRACT

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15-FOOT-DIAMETER MODULAR SPACE STATION KENNEDY SPACE CENTER LAUNCH SITE SUPPORT DEFINITION
(SPACE STATION PROGRAM PHASE B EXTENSION DEFINITION)

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DESCRIPTIVE TERMS

SPACE STATION PROGRAM SHUTTLE LAUNCH SITE, KENNEDY SPACE CENTER (KSC), LUT, VAB, MSOB, KSC SUPPORT OF ORBITAL OPERATIONS, TEST PHILOSOPHY, MISSION SUPPORT VEHICLE, MODULAR SPACE STATION

ABSTRACT

THIS DOCUMENT, SUPPLEMENTS SD 70-545 (DRL-59), FULFILLS A REQUIREMENT TO PROVIDE A SINGLE DOCUMENT THAT DEFINES ALL REQUIREMENTS AND OPERATIONAL PLANS REQUIRED TO SUPPORT THE MODULAR SPACE STATION (MSS) AT KSC, THE ASSUMED SHUTTLE LAUNCH SITE. LESS EMPHASIS IS PLACED ON THE ASSESSMENT OF FACILITIES AND GSE THAN IN SD 70-545, BUT A SECTION HAS BEEN ADDED TO ASSESS THE KSC CAPABILITY TO SUPPORT ORBITAL OPERATIONS.

THIS DOCUMENT DEFINES THE FACILITIES, EQUIPMENT, AND OPERATIONAL PLANS REQUIRED TO SUPPORT THE MSS PROGRAM AT KSC. INCLUDED IS AN ANALYSIS OF KSC OPERATIONS, A DEFINITION OF FLOW PLANS, FACILITY UTILIZATION AND MODIFICATIONS, TEST PLANS AND CONCEPTS, ACTIVATION, AND TRADEOFF STUDIES. EXISTING GSE AND FACILITIES THAT HAVE A POTENTIAL UTILIZATION ARE IDENTIFIED, AND NEW ITEMS ARE DEFINED WHERE POSSIBLE.

THIS STUDY CONCLUDES THAT THE EXISTING FACILITIES, INCLUDING THE MSOB, CIF, VAB, LUT, FIRING ROOM, AND LAUNCH PAD, ARE SUITABLE FOR USE IN THE SPACE STATION PROGRAM WITHOUT MAJOR MODIFICATION FROM THE SATURN-APOLLO CONFIGURATION.

THE STUDY ALSO CONCLUDES THAT MODULARIZATION OF THE SPACE STATION WILL REQUIRE A CONSIDERABLY DIFFERENT TEST CONCEPT, BOTH FOR THE LAUNCH AND PRELAUNCH VERIFICATION. THE CONCEPT EXTENDS THE LAUNCHING AND SUPPORT OPERATIONS OVER A PERIOD OF SEVERAL YEARS AND, CONSEQUENTLY, WILL CHANGE THE ROLES OF THE MANUFACTURING AND LAUNCH SITE FROM THOSE GENERALLY ACCEPTED FOR THE 33-FOOT-DIAMETER SPACE STATION OR PAST PROGRAMS.

FOREWORD

This document is one of a series required by Contract NAS9-9953, Exhibit C, Statement of Work for Phase B Extension-Modular Space Station Program Definition. It has been prepared by the Space Division, North American Rockwell Corporation, and is submitted to the National Aeronautics and Space Administration's Manned Spacecraft Center, Houston, Texas, in accordance with the requirements of Data Requirements List (DRL) MSC-T-575, Line Item 61.

Total documentation products of the extension period are listed in the following chart in categories that indicate their purpose and relationship to the program.

ADMINISTRATIVE REPORTS	TECHNICAL REPORTS		STUDY PROGRAMMATIC REPORTS	DOCUMENTATION FOR PHASES C AND D	
				SPECIFICATIONS	PLANNING DATA
EXTENSION PERIOD STUDY PLAN DRL-62 DRD MA-207T SD 71-201	MSS PRELIMINARY SYSTEM DESIGN DRL-68 DRD SE-371T SD 71-217	MSS DRAWINGS DRL-67 DRD SE-370T SD 71-216	EXTENSION PERIOD EXECUTIVE SUMMARY DRL-65 DRD MA-012 SD 71-214	MSS PRELIMINARY PERFORMANCE SPECIFICATIONS DRL-66 DRD SE-369T SD 71-215	MSS PROGRAM MASTER PLAN DRL-76 DRD MA-209T SD 71-225
QUARTERLY PROGRESS REPORTS DRL-64 DRD MA-208T SD 71-213, -235, -576	MSS MASS PROPERTIES DRL-69 DRD SE-372T SD 71-218, -219	MSS MOCKUP REVIEW AND EVALUATION DRL-70 DRD SE-373T SD 71-220			MSS PROGRAM COST AND SCHEDULE ESTIMATES DRL-77 DRD MA-013(REV. A) SD 71-226
FINANCIAL MANAGEMENT REPORTS DRL-63 DRD MF-004	MSS INTEGRATED GROUND OPERATIONS DRL-73 DRD SE-376T SD 71-222	MSS KSC LAUNCH SITE SUPPORT DEFINITION DRL-61 DRD AL-005T SD 71-211			MSS PROGRAM OPERATIONS PLAN DRL-74 DRD SE-377T SD 71-223
	MSS SHUTTLE INTERFACE REQUIREMENTS DRL-71 DRD SE-374T SD 71-221	INFORMATION MANAGEMENT ADVANCED DEVELOPMENT DRL-72 DRD SE-375T SD 72-11			
	MSS SAFETY ANALYSIS DRL-75 DRD SA-032T SD 71-224				

The analysis described in this report was conducted under the Space Station Definition Study (Phase B) Change Order No. 5, Revision No. 1, to Contract NAS9-9953—Add-On Effort to the KSC Launch Support Study.

This report summarizes the results of the North American Rockwell Space Division (NRSD) analysis of the requirements and definition of operational plans required to support the modular space station (MSS) at the Kennedy Space Center (KSC).

Contract Change Authorization No. 3 (CCA-3) to the basic contract required a definition of all facilities, equipment, and operational plans required to support the 33-foot-diameter space station program at KSC. This definition was given in SD 70-545 (DRL-59) 33-foot-diameter Space-Station, Kennedy Space Center, Launch Site Support Definition. CCA-5 (a follow-on to CCA-3) provided for an increased depth of analysis in specific areas and added some items not included previously in the study. Shortly after the study was begun, the Phase B extension to the contract was initiated and the program emphasis was changed to the modular space station. CCA-5 was revised and combined with the Phase B extension to produce information more in consonance with the revised program objectives and budget allocations. The level of effort was reduced, the time period extended, the number of task items decreased, and the emphasis for the combined study was changed to the shuttle-launched version of the space station.

CCA-5 required that a separate supplemental document to SD 70-545 (DRL-59) be submitted, while the Phase B extension statement of work stipulated that the KSC Launch Site Operations Report be included as a section of the Modular Space Integrated Ground Operations document SD 71-222 (DRL-73). This report (SD 71-211) was prepared in compliance with CCA-5; and the data appropriate to fulfill the SD 71-222 requirements will be extracted from this report.

CONTENTS

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ILLUSTRATIONS

TABLES

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ABBREVIATIONS

ABES	Air-breathing engine system
ACE	Acceptance checkout equipment
AFETR	Air Force Eastern Test Range
AVU	Audio-video unit
BOL	Beginning of life
CAV	Compatibility assessment vehicle
CCA	Contract change authorization
CCTV	Closed-circuit television
CH_4	Methane
CM	Cargo module flight
CMG	Control moment gyro
CO_2	Carbon dioxide
CRT	Cathode-ray tube
CSM	Command space module
C1	Core module 1 - flight
C2	Core module 2 - flight
C1-C	Core module - CAV
C2-MS	Core module - MSV (was dynamic test module)
C^2F^2	Crew compartment fit and functional
DP	Dewpoint

DPA	Data processor assembly
DRAM	Detached RAM
DRL	Data requirements list
ECLSS	Environmental control and life support subsystem
EEG	Electroencephalogram
EKG	Electrocardiogram
EMC	Electromagnetic compatibility
EMG	Electromyograph
EMT	Electronic microscope - table model
EOL	End of life
EOSS	Earth orbiting space station
EPS	Electrical power subsystem
ESE	Electrical support equipment
EVA	Extravehicular activity
FC	Fuel cell
FMCV	Flight module checkout vehicle
FPE	Functional program element
G&C	Guidance and control
GFY	Government fiscal year
GPL	General purpose laboratory
GPL/AL	General purpose laboratory airlock
GRU	Ground replaceable unit
GSE	Ground support equipment

HX	Heat exchanger
H/U	Hookup
H_2	Gaseous hydrogen
ID	Inside diameter
I/F	Interface
IFRU	In-flight replaceable unit
IMS	Information management system
IMU	Inertial measuring unit
ISS	Information subsystem
IVA	Intravehicular activity
KSC	John F. Kennedy Space Center
LCC	Launch control center
LCG	Liquid-cooled garment
LC-39	Launch complex 39
LH_2	Liquid hydrogen
LiOH	Lithium hydroxide
LO_2	Liquid oxygen
LUT	Launcher umbilical tower
M/A	Monitor alarm
MSF	Maintenance and checkout facility
MSOB	Manned Spacecraft Operations Building
MSS	Modular space station
MSV	Mission support vehicle (was flight module checkout vehicle)

NASA	National Aeronautics and Space Administration
NR	North American Rockwell Corporation
N_2	Gaseous nitrogen
OBCO	On-board checkout
OD	Outside diameter
ODAPT	Orientation drive and power transfer
OIS	Operational intercommunications system
OPS	Operational paging system
OTV	Operational television
O_2	Gaseous oxygen
PIB	Pyrotechnic Installation Building
PGA	Pressure garment assembly
PLSS	Portable life support system
PM	Power module - flight
PM-C	Power module - CAV (was structural test power module)
PM-MS	Power module - MSV 9 was PM-C)
QLDS	Quick-look data station
RACU	Remote acquisition and control unit
RAM	Research and applications module
RCS	Reaction control subsystem
RF	Radio frequency
S/C	Spacecraft
SM-1	Crew/control station module 1 - flight

SM-2	Laboratory/atmosphere management station module 2 - flight
SM-3	Laboratory/dining/atmosphere management station module 3 - flight
SM-4	Crew/control station module 4 - flight
SM-5	Crew/ECS station module 5 - flight
SM-6	Crew/ECS station module 6 - flight
SM-1C	Station module 1 - CAV
SM-3C	Station module 3 - CAV (was structural test common module)
SM-4C	Station module 4 - CAV (was dynamic test common module)
SM-1-MS	Station module 1 - MSV (was SM-1C)
SM-3-MS	Station module 3 - MSV (was SM-3C)
SM-4-MS	Station module 4 - MSV (was SM-4C)
TBD	To be determined
TDRS	Telemetry data relay station
TLM	Telemetry
UCDC	Universal control and display console
UTE	Universal test equipment
VAB	Vehicle Assembly Building
V/C	Vapor/compressor
X-POP	X-axis perpendicular to the orbital plane
Y-POP	Y-axis perpendicular to the orbital plane
Z-POP	Z-axis perpendicular to the orbital plane

1.0 SPACE STATION DESCRIPTION AND PROGRAM SUMMARIZATION

The Space Station Program was initiated by NASA in September 1969 with the awarding of a Phase B contract to define a space station program and system element preliminary designs for a Saturn-launched station. The study was completed in July 1970 and concentrated on the concept selection and preliminary design of a 33-foot-diameter, solar-powered space station (Station A) for on-orbit operation in 1977. CCA-3 to Contract NAS9-9953 was issued to define the facilities, equipment, and operational plans required to support this station at Kennedy Space Center.

Subsequent to the above, it was considered expedient to conduct a similar study for a space station that would be totally dependent upon the shuttle as a launch vehicle. The approach required the station to be built of separate modules that could be individually placed in earth orbit and configured to provide an essentially permanent facility. A study similar to that for the 33-foot-diameter space station was initiated by NASA in February 1971 to define a space station program predicated on the shuttle-launched modular concept. This particular document is considered to be a portion of the study results, but the study emphasis was placed on the operations and information pertinent to the Kennedy Space Center.

This section of the report provides a brief description of the modular space station (MSS), the mission support vehicle (MSV), the shuttle model definition assumed for the study, and general background information and reference material that is common to more than one section of the document in order to reduce duplication.

For the purpose of this study, it is assumed that both the MSV and the shuttle launch site are located at the Kennedy Space Center. A description of the present KSC launch site was given in SD 70-545-1 and thus will not be repeated in this report, because it is assumed that both reports will have essentially the same distribution.

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1.1 PROGRAM REQUIREMENTS AND GUIDELINES

The long-term objectives of the modular space station (MSS) program are the same as those stated for the 33-foot-diameter station program; however, buildup to this capability might occur over a longer period with lower yearly funding. The MSS will have the capability of growth from an initial space station having fully configured subsystems and accommodating six crewmen to a growth space station equivalent in capability to the zero-g, 12-man, 33-foot-diameter configurations defined in the original studies. The planned launch of the first space station module will be in July 1981, and the growth space station is expected to reach full operational capability in 1987.

The station is designed for use in an orbit with an inclination of 55 degrees at an altitude between 240 and 270 nautical miles (nm). Shuttle launch frequency to support the station program will be no greater than one shuttle every 30 days; and the initial station shall have the capacity for independent operations with the full crew for a period of 120 days.

System concepts for the modular approach offer program flexibility by providing a series of capability plateaus that achieve useful benefits but allow deferment of development and operational costs. The principal operational requirements are derived from configuration buildup operations and operations associated with the performance of the candidate experiments. The space station candidate experiments consist of 25 functional program elements (FPE's) that subdivide into 221 experiments. The scheduling of these experiments is based on the availability of space station resources.

Commonality is a primary consideration throughout the study. As a goal, common module structures, systems and subsystems for space station modules, cargo modules, and research and applications modules should be developed. The development approach is to provide the basis for reducing the number and cost of test articles and major tests and utilize hardware and GSE previously developed for the shuttle when feasible.

Safety is a mandatory consideration through the total program. No single malfunction or credible combination of malfunctions and/or accidents shall result in serious injury or to crew abandonment of the space station.

Cost of the program is a primary consideration.

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1.2 MODULAR SPACE STATION DESCRIPTION

A Phase B definition of a space station program and system element preliminary designs for a Saturn-launched station were completed and considered the use of the space shuttle as the logistics vehicle. This station was designated Space Station A, was solar-powered, and 33 feet in diameter. NR subsequently conducted a Phase A Conceptual Analysis of a Modular Space Station under the Program Phase B definition options study period and a Phase B analysis of the MSS under the Phase B extension. The MSS description in the following paragraphs is primarily for the station established as a baseline as a result of the Phase B study. However, because the KSC portion of the study was conducted concurrently with the preliminary design analyses, some of the KSC studies were necessarily predicated on the Phase A information. These instances are noted in the report. Typically, the cargo module was based on the Phase A concept, which utilized cryogenics but was not updated during the Phase B extension to be in consonance with the changes resulting from that study and which deleted cryogenics.

1.2.1 SPACE STATION CONFIGURATION

Trade and special studies were performed in establishing the preferred modular space station approach. Consideration was given to program, operations, configuration, subsystems, and safety. The drivers in selecting a flight mode were identified to be heat rejection requirements and capability and experiment support requirements. All other functions were relatively insensitive to flight mode selection in that physical location requirements within the complex could be satisfied. A requirement exists to maintain a minimum of two separate and pressurized habitable volumes with independent life support capability at each stage of manned buildup and operation. At least two egress paths shall be available from each module for emergency egress of personnel during manned ground operations.

The design weight of the modules was limited to 20, 000 pounds, and the external dimensions were restricted to 14 feet in diameter and 58 feet in length so that they could be contained in the 15-ft by 60-ft cargo bay or payload envelope of the shuttle orbiter.

Figure 1.2-1 is a sketch of the initial 6-man station and the 12-man growth station, which represents the configuration to be used in this study. It is characterized by tightly spaced modules in the form of a cruciform arrangement.

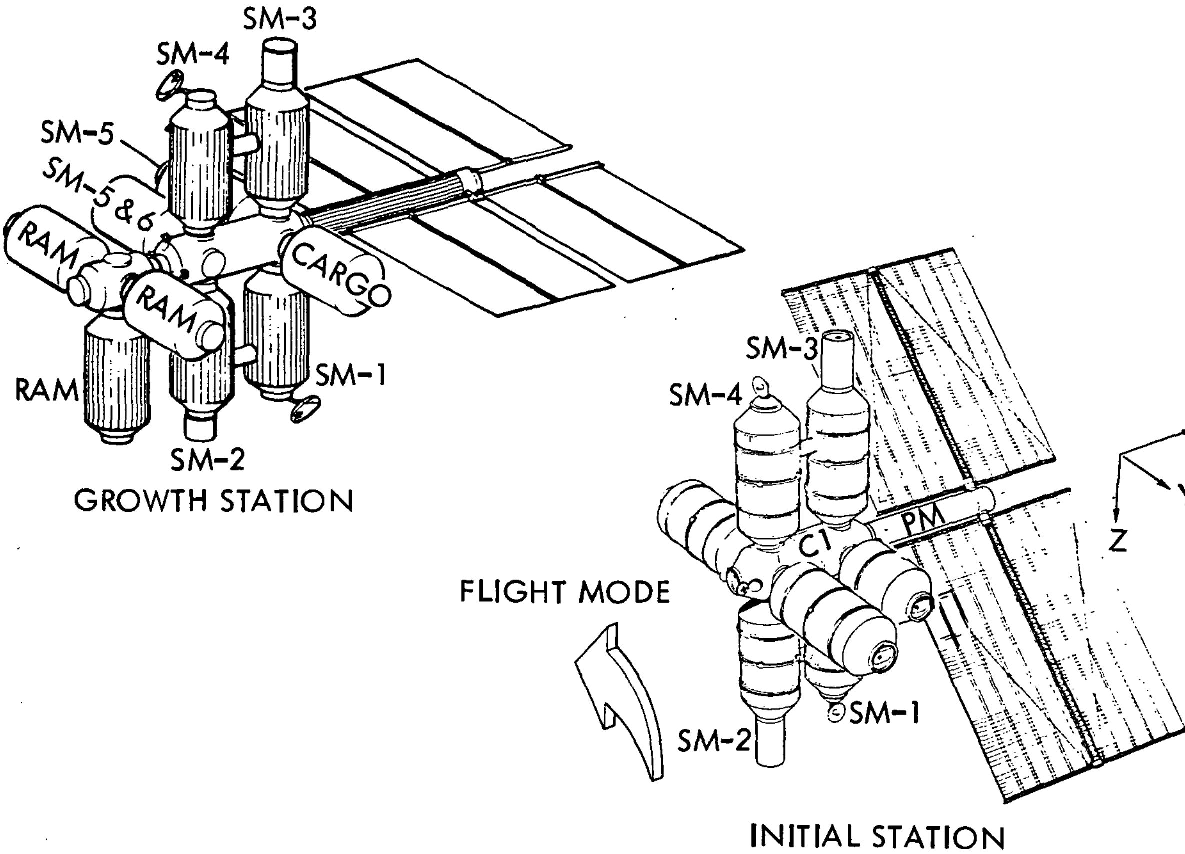


Figure 1.2-1. Cruciform Concept

A 5-foot spacing has been established between adjacent modules, which is compatible for modular clearance as well as the length of the core module for stowage of internal and external equipment (hatches, guidance and navigational equipment, airlock, etc.,). Dual egress from each volume has been provided by use of a flexport (36-inch-diameter inflatable tunnel) attached to each module. The extension and installation of the flexport between adjacent modules is accomplished after the modules are attached to the core module.

The modules are not self-contained nor are they completely independent. Requirements exist for the transfer of data, command, power, fluids, and gases across the berthing interfaces. Also, the availability of utilities at the interface is fundamental to the station support functions for the experiments. The utilities interface is an integral part of the berthing and docking assembly. Because of the potentially large numbers of different flight elements that may be docked to the station or to each other, a neuter docking concept was selected to eliminate the programming associated with male and female docking systems. This concept is discussed in Section 2.1.6 of this report.

1.2.2 MODULE CONFIGURATION

The MSS is composed of distinct elements (modules) which, when assembled, provide necessary support for experiments and applications. The initial station is composed of a core, a power module, and four station modules. Cargo modules and research and application modules (RAM's) are added and replaced as required. The power and core modules are unique structures, but the remaining modules utilize the same structural arrangement. Additional detail and system allocations are given in Section 2.0.

A clarification of the names or titles of the modules and their abbreviations is given in Table 1.2-1.

Table 1.2-1. Modular Space Station Titles and Abbreviations, Preferred Configurations

Title	Abbreviation
Modular Space Station	MSS
Power Module	PM
Initial Core Module 1	C1
Initial Core Module 2	C2
Crew/Control Station Module 1	SM-1
Laboratory/Environmental Control Station Module 2	SM-2
Laboratory/Environmental Control Station Module 3	SM-3
Crew/Control Station Module 4	SM-4
Crew/ECS Station Module 5	SM-5
Crew/ECS Station Module 6	SM-6
Cargo Module	CM
Research and Application Module	RAM

1.2.2.1 Common Modules

The design goal is a common primary structure for the station, crew/cargo, and RAM modules. It is a low-cost monocoque structure using 0.145-inch 5052 aluminum alloy, is 14 feet in diameter, and 38 feet 8 inches in length from docking interface to docking interface. The exterior of the module is enclosed by an environmental shield of 0.03-inch aluminum, which serves as a meteoroid bumper and includes the radiators if utilized for a specific module. Kapton-lined insulation is located inside the meteoroid bumper and acts as a secondary bumper. Three frames are utilized external to the pressure shell and accommodate the shuttle attach points and the manipulator sockets.

The interiors of the various modules are configured to accommodate the individual requirements; i.e., crew, control, experiment, laboratory, cargo, dining, medical, etc. Included in this category are station module 1 (SM-1) through SM-6, the cargo modules, and the RAM's that can be accommodated by this common module structure.

Typical station modules are shown in Figures 1.2-2 and 1.2-3. The control crew module (SM-1) contains a commander and executive type stateroom and two crew staterooms. These rooms are provided in a split-level arrangement. The waste management equipment is located below deck near the personal hygiene area. The control center, data analysis, and the photo laboratory occupy the remainder of the upper deck area. SM-3 provides laboratory facilities for the physics and biomedical experiments. The zenith airlock is located at the laboratory end of the module. The air revitalization equipment for Volume 1 is below deck in this module, and the galley and dining functions are located above deck.

1.2.2.2 Core Module

The conceptual design of the initial core module (C1) is shown in Figure 1.2-4. The core module is different in size and structural arrangement from the functional modules; it is 12 feet in diameter and 40 feet in length between the end docking ports. It has 10 passive docking ports and is separated into two compartments by a central EVA/IVA airlock. Fuel cells, inverters, and electrolysis units are located on the airlock bulkheads in each compartment. Low-pressure accumulators (300 psi) for the EPS and RCS are installed in the core. Installation of the guidance and control trackers and gyros is provided, and the control moment gyros (CMG's) are positioned near the RAM docking port.

The growth station requires one additional core module (C2) that is approximately one half the length of C1. It has no primary equipment, but contains only extensions of the utilities for the interfacing modules.

1.2.2.3 Power Module

The power module assembly is shown in Figure 1.2-5 and consists of a power boom structure supporting a solar array by means of a turret and drive mechanism. The boom is pressurizable, as required, to provide a shirt-sleeve environment for crew maintenance operations inside the boom and turret. These operations include maintenance and service to the solar array orientation drive mechanism and to the installed electrical system components, power conditioning equipment, and equipment cooling provisions.

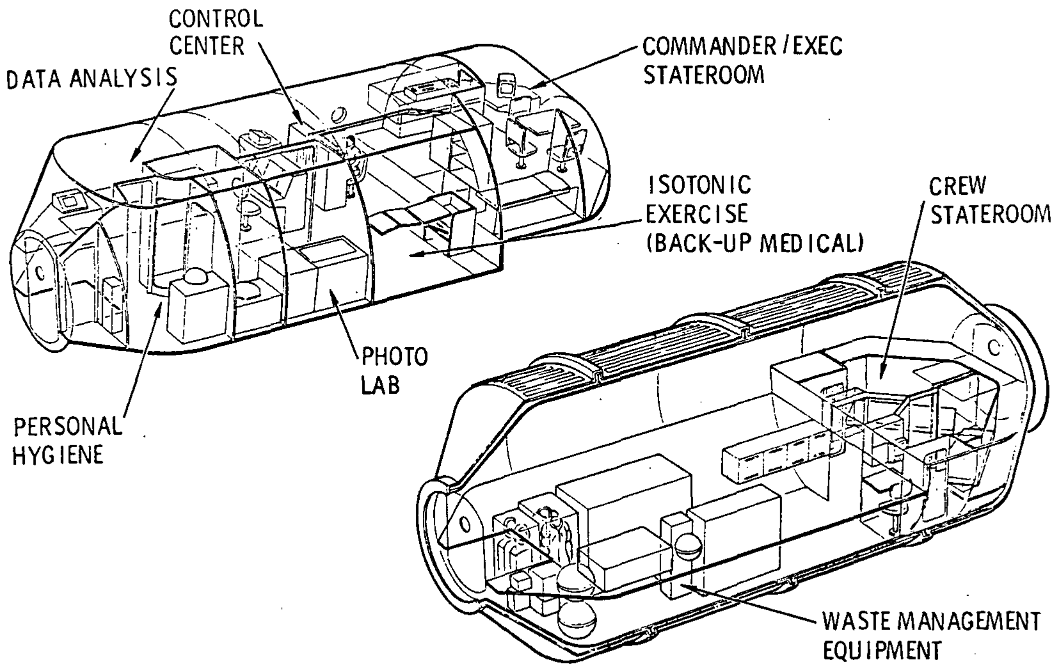


Figure 1.2-2. Module SM-1 Control/Crew

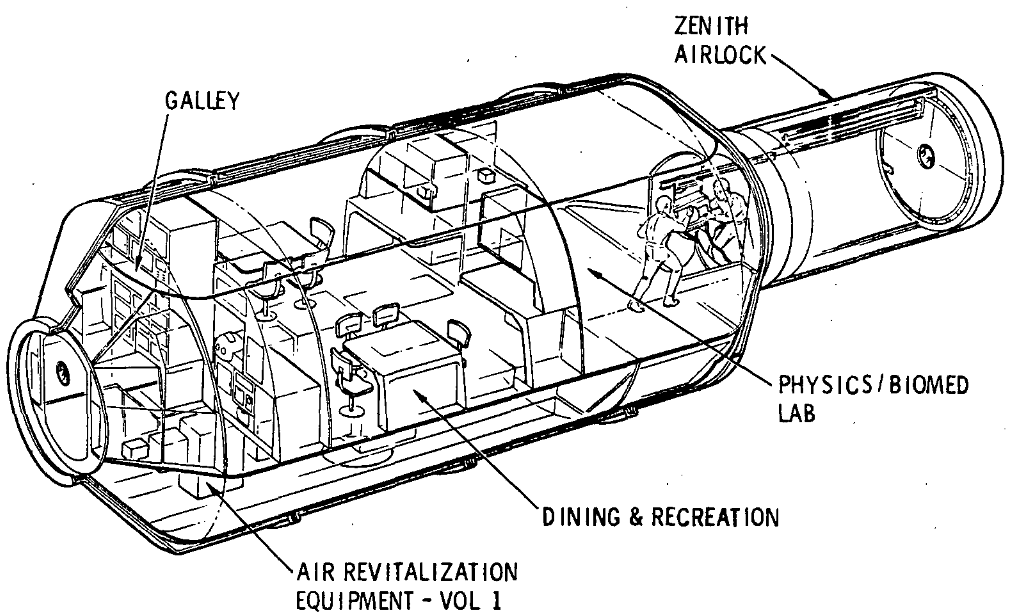
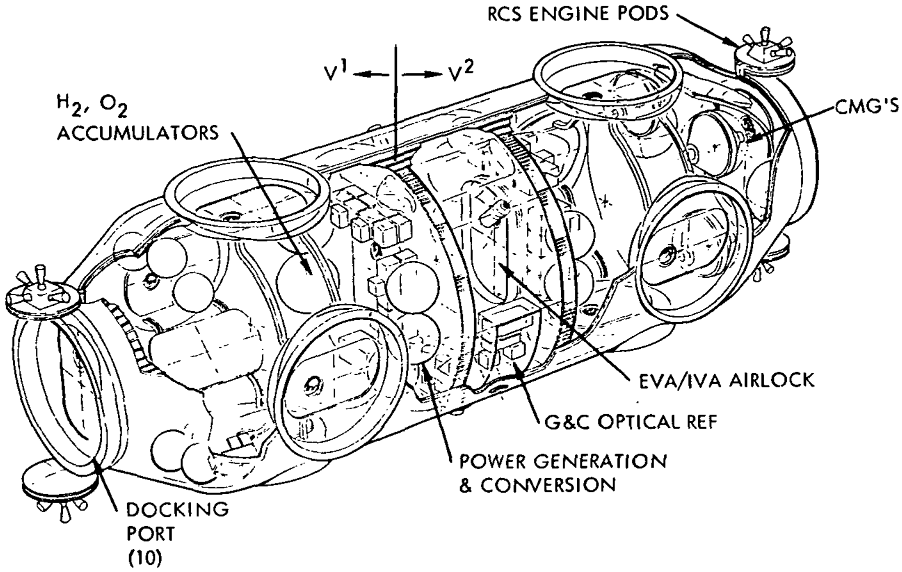


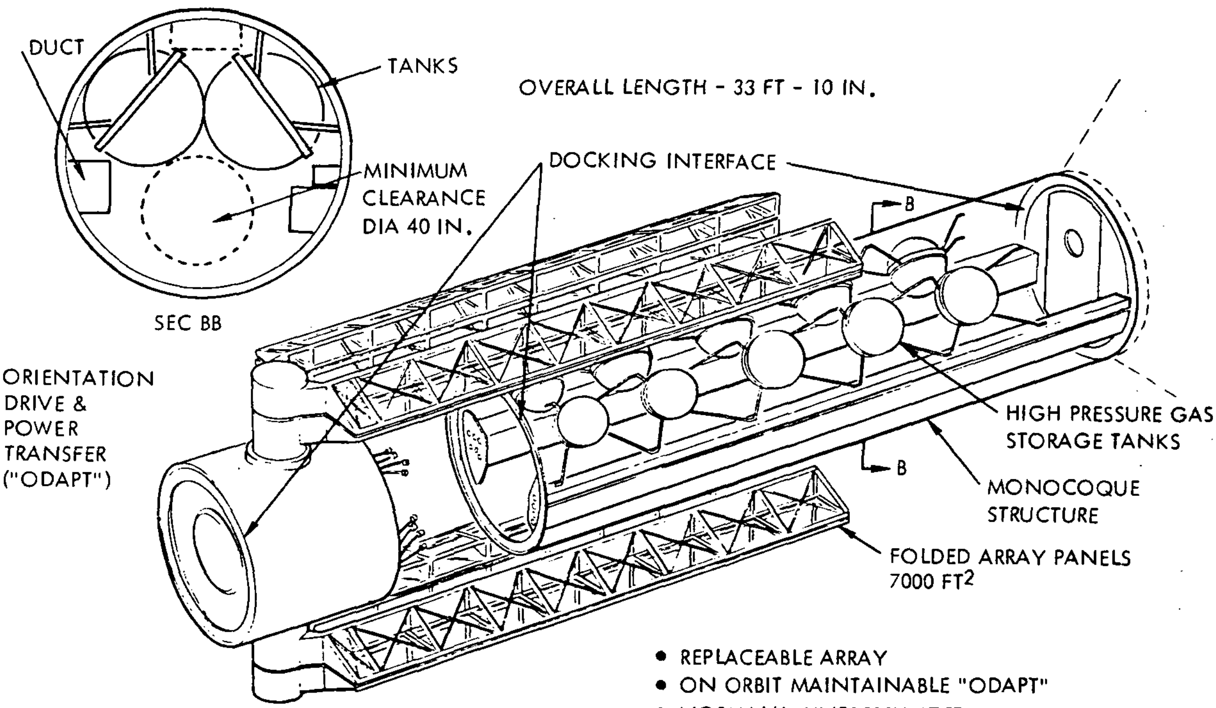
Figure 1.2-3. Module SM-3 Laboratory/Environmental Control



- MAX DIMENSIONS
  LENGTH - 40 FT
  DIA - 15 FT
- MAIN UTILITY DISTRIBUTION
  WIRING
  DUCTS
  PLUMBING
  REDUNDANT & SEPARATED
- DUAL VOLUME SEPARATED FUNCTIONS
- LOW CREW OCCUPANCY
- CENTRALIZE G&C
  RAM INTERFACE
  ALIGNMENT
  STABILITY

- ALL SUBSYSTEMS ON-ORBIT REPLACEABLE
- MODULE SPACING FOR DIRECT DOCKING OR BERTHING
- FIRST MODULE LAUNCHED - MINIMIZES COMPLEXITY OF POWER MODULE
  - REDUCES BUILDUP SCARS

Figure 1.2-4. Initial Core Module



- REPLACEABLE ARRAY
- ON ORBIT MAINTAINABLE "ODAPT"
- NORMALLY UNPRESSURIZED
- ON-ORBIT REPLACEABLE TANKS & EQUIPMENT

Figure 1.2-5. Power Module

A 7000-square-foot solar array is utilized with the initial station. This solar array is replaced with a 10,000-square-foot area solar array for the growth station. The power module contains four high-pressure tanks for repressurization of one module of the station.

1.2.2.4 Cargo Module

The cargo module is intended for the routine resupply and exchange of crews for the solar-powered space station. A complete spectrum of arrangement, structural, and subsystem trades was analyzed in order to select the module's preferred characteristics. The major operational trade study was to determine the preferred mode of operation—either parasitic or self-sufficient.

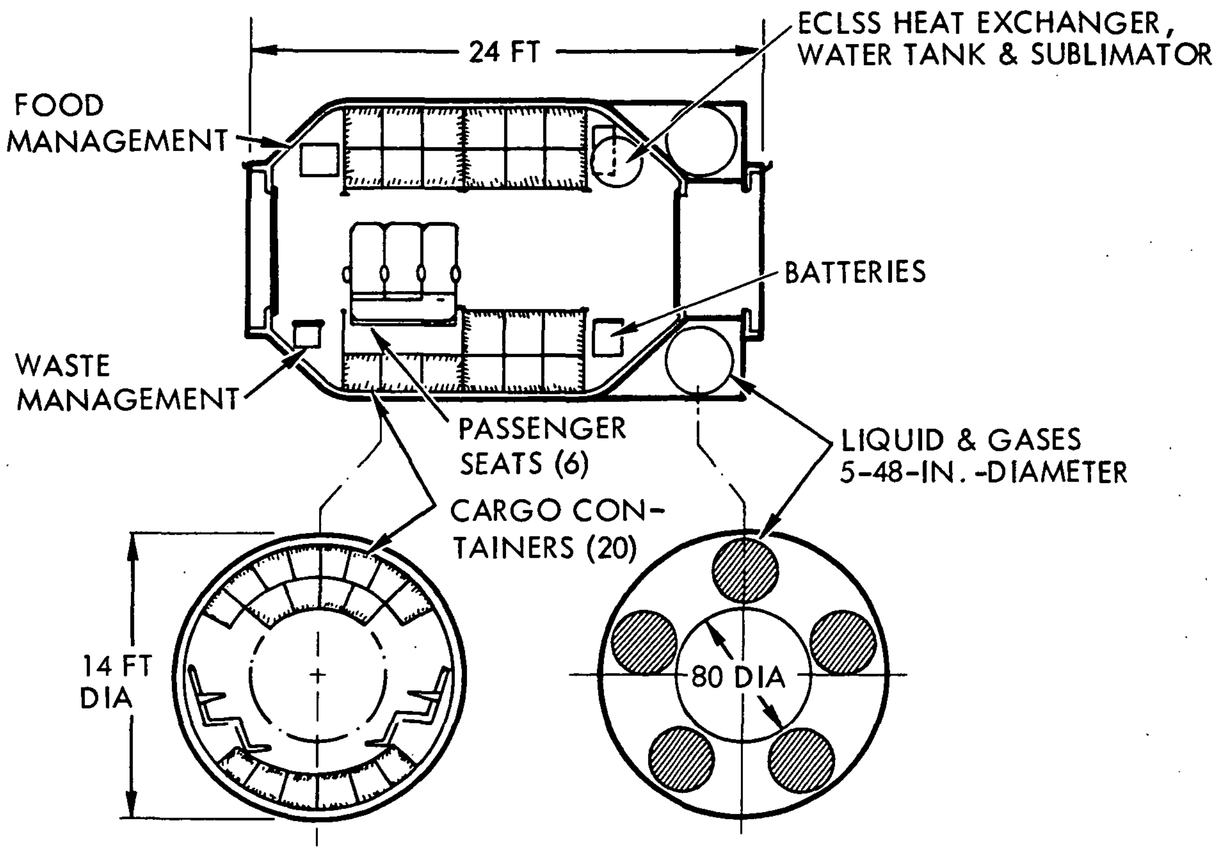
Based upon ground and operational requirements, arrangements and subsystems trade studies, cost analyses were conducted to arrive at the preferred operational mode. Although the parasitic concept was less expensive, its cost impact on the shuttle to supply the necessary functions, primarily electrical power and environment control, produced much higher overall program costs than did the self-sufficient concept. From this standpoint, the self-sufficient concept was selected as the preferred mode of operation.

Figure 1.2-6 illustrates the selected concept and its basic internal arrangement; i.e., all-cargo and combined cargo and 6-man crew for space station crew rotation or emergency evacuation flights. Extra seats will be added for emergency evacuation of the growth station crew. The arrangement shown in the figure has been developed based on considerations for crew and space station safety and the utility associated with cargo loading and unloading procedures. The primary subsystems consist of batteries for electrical power and a simple water boiler and heat exchanger for thermal control. LiOH is used for CO_2 removal, while metabolic oxygen is supplied by the space station LO_2 resupply tanks.

For all-cargo flights, many of the passenger provisions such as seats in the cargo module are not carried to maximize useful cargo. Additional information and details for these cargo flights are given in Section 4.0.

1.2.3 SUBSYSTEMS

The MSS subsystems are similar to those of the 33-foot-diameter space station. They have, however, been reconfigured to be compatible with the modular station concept. Some changes have been made as a result of more detailed studies. The functional subsystems are shown in Figure 1.2-7. Descriptions of the major assemblies are given in Section 2.0.



SUBSYSTEMS

INFORMATION SUBSYSTEM

COMMUNICATIONS

DATA MANAGEMENT

ELECTRICAL SUBSYSTEM

LIGHTING

CREW & HABITABILITY SUBSYSTEM

PERSONAL HYGIENE

ENVIRONMENTAL THERMAL CONTROL & LIFE SUPPORT SUBSYSTEM

ATMOSPHERIC CONTROL
THERMAL CONTROL
WATER MANAGEMENT
WASTE MANAGEMENT
FOOD MANAGEMENT

STRUCTURES SUBSYSTEM

PRIMARY STRUCT
SECONDARY STRUCT
BERTHING PORT

Figure 1.2-6. Cargo Module

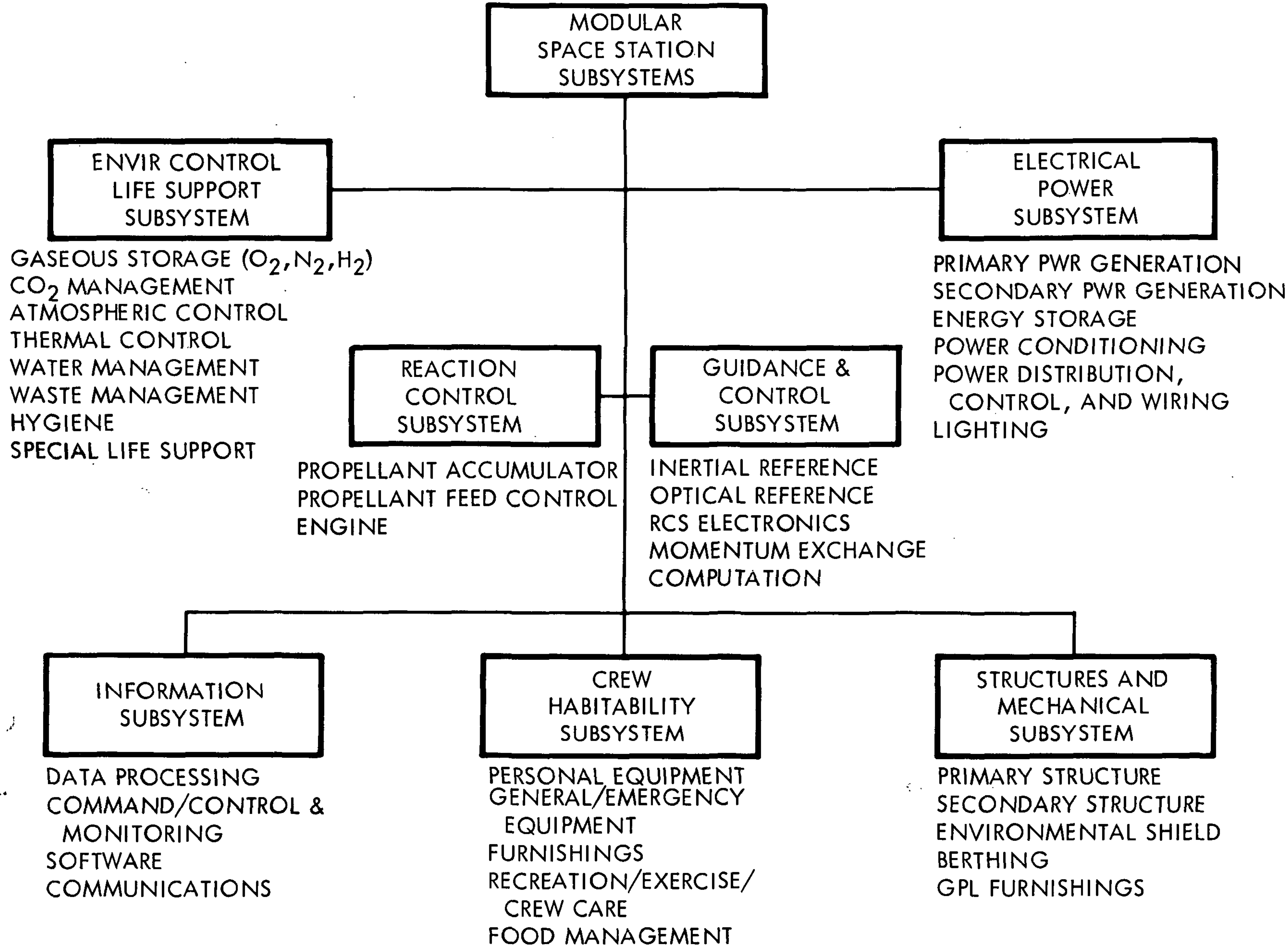


Figure 1.2-7. Modular Space Station Subsystems

1.2.4 EXPERIMENTS

The space station configuration is dependent upon the experiments that are to be conducted and the sequence in which they are scheduled. The experiments were assigned to the following priority categories:

I. Social and economic benefits
II. Earth-oriented scientific benefits
III. High-priority scientific knowledge
IV. General scientific knowledge

One hundred and sixty-two experiments were identified and categorized in SD 70-545. Additional detail will not be included in this report, because the subject of experiments, payloads, and concepts of implementation are presently undergoing extensive re-evaluation and revision.

The scheduling of the experiments can be initiated at any time in the program that the basic operational capability exists and the experiment equipment is available. The detailed scheduling of experiments is dependent upon the resources and facilities available. These, in turn, are dependent upon the level of buildup and the crew size that can be accommodated. One of the principal constraining resources is crew time available for experiments, which is defined as the total crew time available less those man-hours required for space station operations. Based on a total crew size of 6 and a 10-hour work shift, the equivalent of approximately 4 men is available for experiment operations for the initial modular space station. The equivalent of 9 men is available for experiment operations for the growth configuration based on a total crew size of 12.

1.2.5 BUILDUP SEQUENCE

Configuration buildup of the space station basically consists of delivery of facilities to orbit necessary to support manned orbital operations and to conduct the experiments program. These facilities must be designed into the modules and the modules delivered to orbit in a preferential sequence. A summary of the initial station configuration is shown in Figure 1.2-8. Details of each module are given in Section 2.0.

The assembly period of the modular space station has been constrained by a guideline that permits only one shuttle orbiter flight over a 30-day period. This constraint leads to periods of unmanned operations. The functions required during the various phases of buildup impose unique demands on the vehicle design. The orbiting cluster must have the capability for

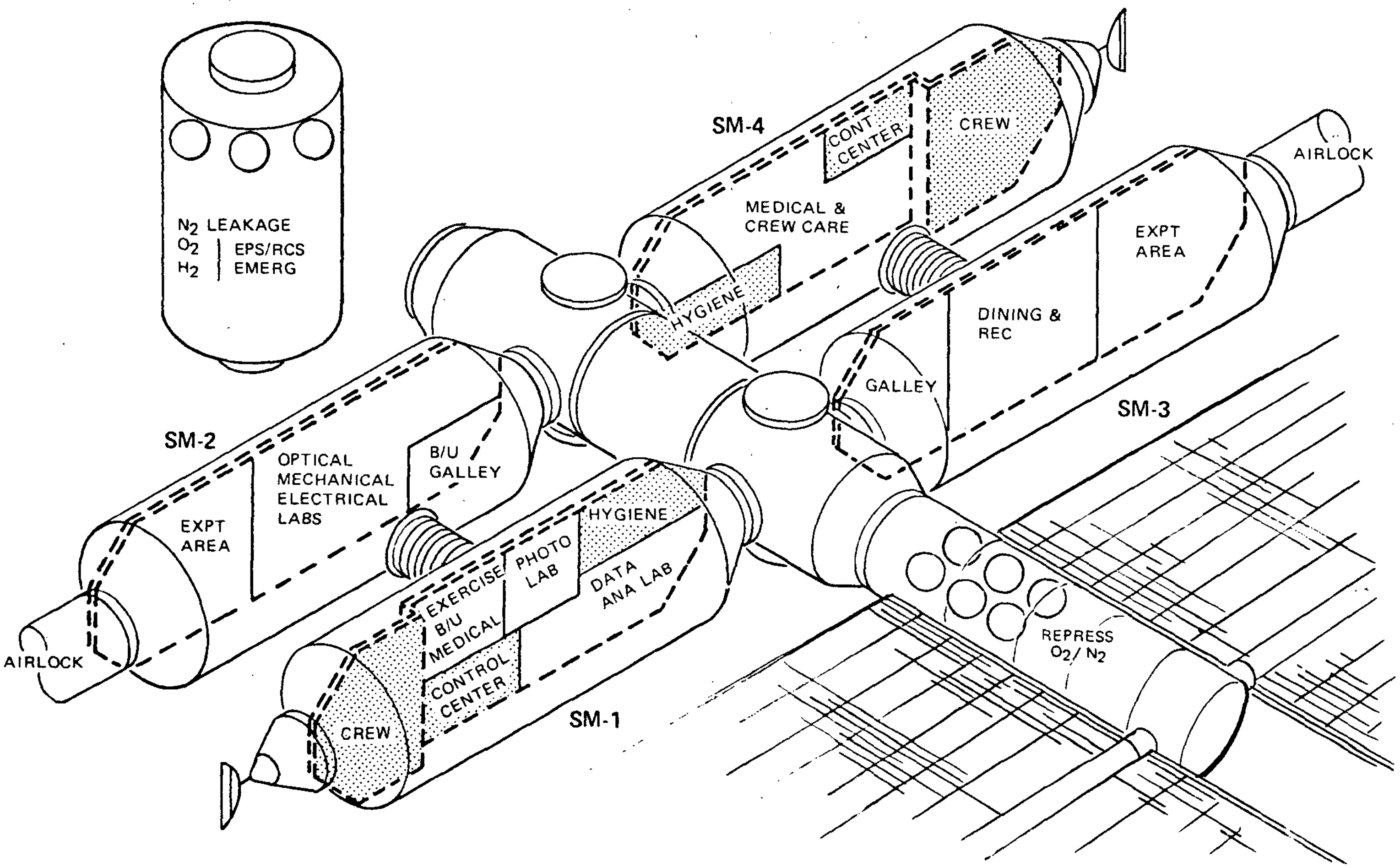


Figure 1.2-8. Initial Station Configuration Summary

attitude stabilization both autonomously and by remote command to permit shuttle berthing. Assurance of a habitable environment to permit checkout and activation of each added module is necessary. Also, provisions must be made for monitoring the space station systems while in the unmanned condition.

1.2.5.1 Module Buildup Sequence Selection

Trade studies were conducted to determine the most logical and economical sequence. The buildup is initiated by delivery of the core and power modules. The core module is delivered first in view of the considerations summarized in Figure 1.2-9.

The initial module to be delivered to orbit preferably would have the minimum amount of scar equipment over and above that required for normal operations. The figure shows that, although the power module provides early delivery of abundant power, many additional functions must be added to the module to support that power source. The core module alternative permits use of the normally installed secondary power source and requires minimal support functions. It must provide attitude stabilization and control in order to permit berthing of subsequent modules. This requires energy storage, guidance and control equipment, RCS quads, propellant storage, thermal control, and subsystem monitoring and control upon demand.

As illustrated in Figure 1.2-10, the delivery of subsequent modules follows a similar logic in limiting scar equipment. The power module was chosen for the second launch because of its limited need for added support, particularly with the arrays retained in a retracted condition. The third launch provides a full information subsystem capability permitting array deployment, attitude control, and heat rejection capability.

The resultant buildup to the initial station is summarized in Figure 1.2-11. A potential early manning plateau exists at step 4, and the option exists to deliver the step 5 ECS/laboratories module at step 4 rather than as shown.

The growth station capability is achieved by the addition of two station modules with crew quarters and life support and by the addition of a short core with added fuel cell/electrolysis equipment. The solar array is increased to 10,000 square feet. The sequence is shown in Figure 1.2-12.

1.2.5.2 Activation and Checkout Requirements

The level of activation during each stage of buildup has been limited to that required for buildup continuation. All requirements are minimized until the solar array power is available. As noted in Section 1.2.3.2,

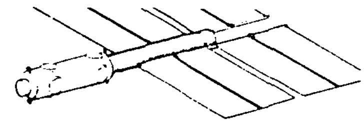
CONSIDERATION	 CORE	 POWER
OPERATIONAL MODE	PASSIVE ATTITUDE CONTROL (GRAVITY GRADIENT)	ACTIVE ATTITUDE CONTROL (SOLAR ARRAY POINTING)
LEVEL OF INITIAL ACTIVATION	MINIMUM ACTIVATION PARTIAL DEACTIVATION PRIOR TO SHUTTLE RETURN	REQUIRES ACTIVATION OF MAJOR ASSEMBLIES
SUBSYSTEM SCARS	EPS, G&C, RCS } NO MAJOR SCARS ECLSS - POTENTIALLY ACTIVE THERMAL CONTROL ISS - "WAKE-UP" RECEIVER & BUILDUP COMM	EPS - PRIMARY BUSSES - EMERGENCY STORAGE G&C - TWO CONCEPTS OR REDUNDANT EQUIPMENT RCS - TWO ADDED QUADS ECLSS - ACTIVE THERMAL LOOPS RADIATORS ATMOSPHERIC CONTROL ISS - DPA
WEIGHT SENSITIVITY	NO SINGLE MAJOR ASSEMBLY DRIVER	SINGLE MAJOR ASSEMBLY DRIVER (SOLAR ARRAY)

Figure 1.2-9. Initial Launch Alternatives

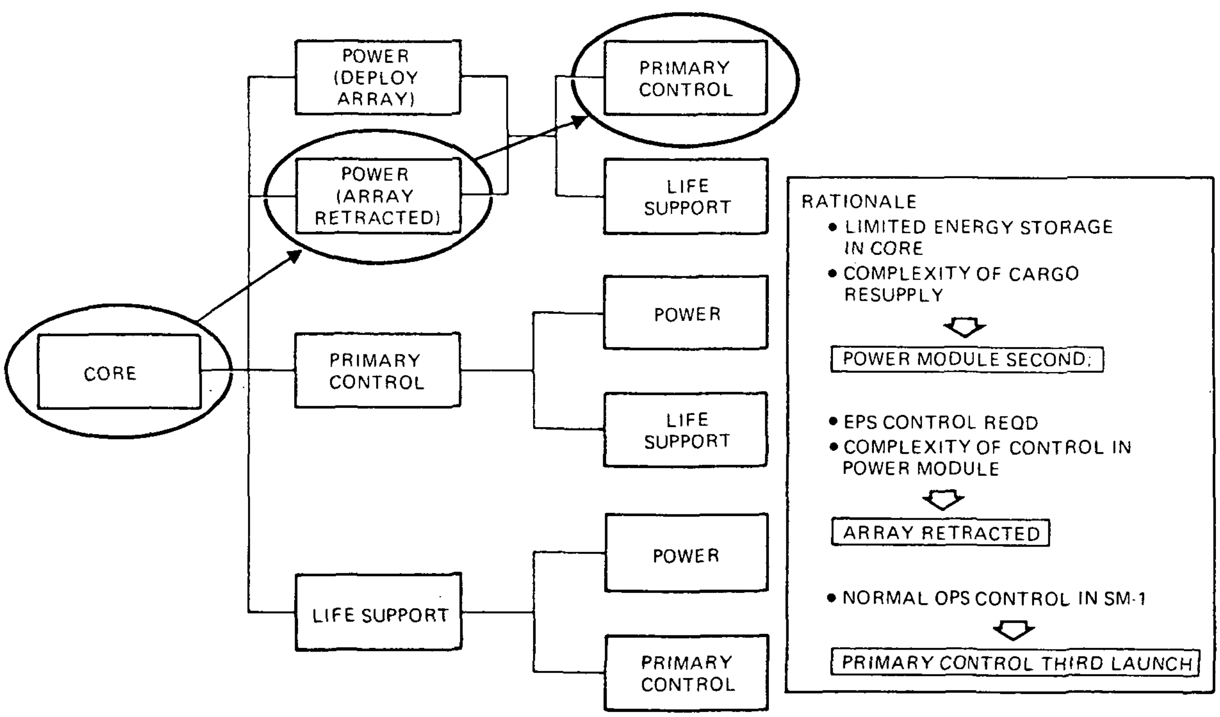


Figure 1.2-10. Subsequent Module Buildup Selection

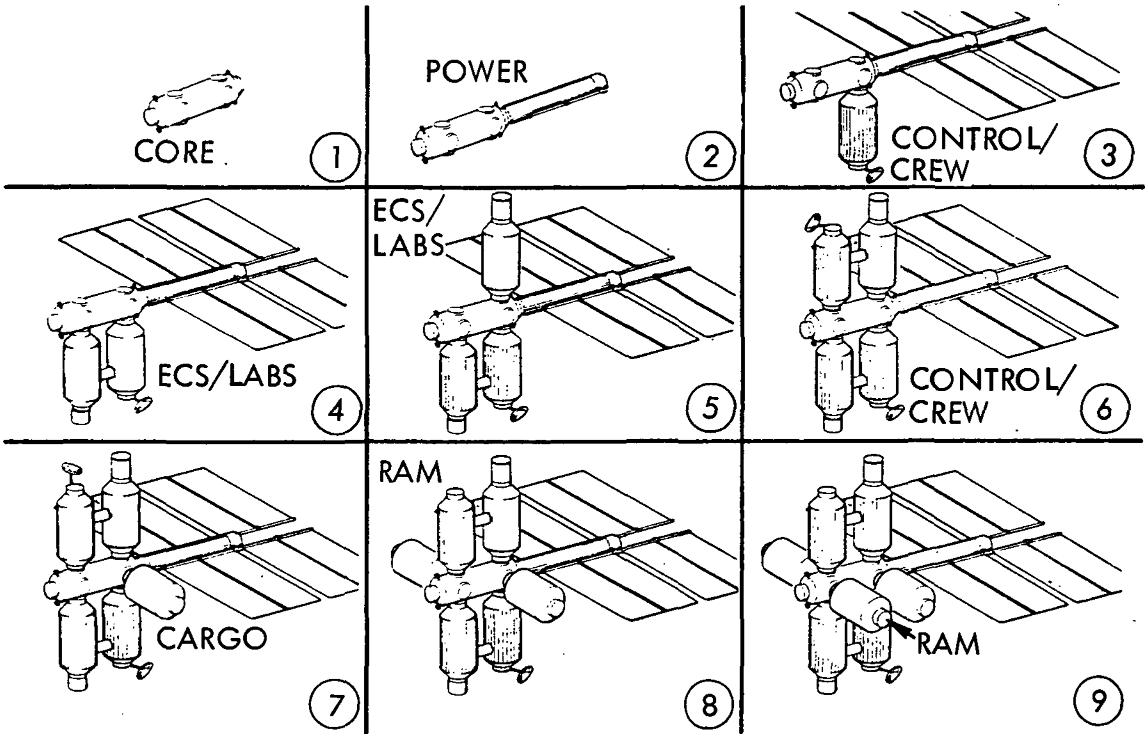


Figure 1.2-11. Building Sequence - Initial MSS

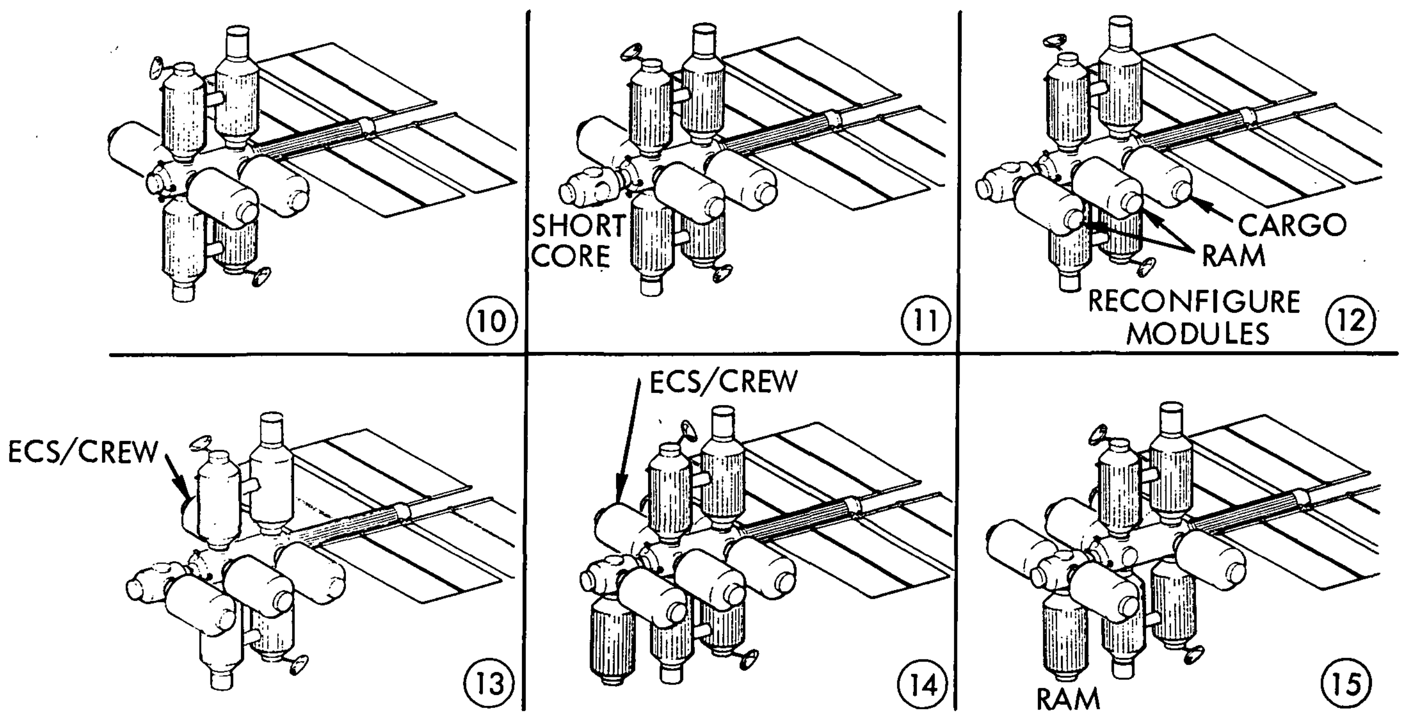


Figure 1.2-12. Buildup to Growth Station

limited power is available through the utilization of the fuel cells, emergency batteries, and the O_2 and H_2 stored in the core and power modules. The fuel cell is activated prior to separation of the core module from the shuttle.

The station is operated in a quiescent mode until manned. Wake-up receivers and circuitry are utilized to bring systems and components on line only when required. The station cluster will be flown in a passive attitude control (gravity gradient) mode until the solar arrays are deployed. However, it would be stabilized for the berthing maneuvers and again after separation from the shuttle with the RCS and remote control. After the solar power system is activated, attitude control will be initiated to maintain the solar arrays in the proper attitude with respect to the sun. Subsystem status is monitored only periodically (1/2 hour per day) to conserve power. Table 1.2-2 lists the functions and approximate power requirements that are indicative of the systems required and the extent of their utilization.

Table 1.2-2. Buildup Functional and Power Requirements (First 60 Days)

Function			24-Hour Average (watts)	Peak (watts)
ECS thermal control		Fan 30 w H_2O pump 60 w Freon pump 35 w Atmosphere monitor 35 w	160	160
		Sensitive heat exchanger		100
IMU			160	160
ISS	(Telemetry and tracking; attitude stabilization for berthing)	Communications 65 w Data processing 75 w Instrumentation 20 w RCS electrical 40 w		0 to 200
Wake up receivers			30	30
EPS sequencers			5	5
	Electrical load		355	655
	EPS losses		60	110
Total energy requirements (30-day)			290 kwh	14.9 kwh

w - watts
kwh - kilowatt-hours

The average and peak power requirements are illustrated in Figure 1.2-13. It should be noted the power module imposes no additional continuous power requirements, and thus the second 30-day period would be essentially the same as that shown for the core module.

The quiescent mode operational concept and control and signal flow during the early period are illustrated in Figure 1.2-14.

The control module is the third module to be added to the station. This addition permits activation of attitude control and the solar power system. The assembly activation and checkout requirements for all of the MSS initial station modules are shown in Figure 1.2-15.

It should be noted that such functions as CO_2 management are not activated until buildup is complete and the continuous manned operations are initiated. Reaction control system (RCS) usage is limited in the first two deliveries to that required for berthing stabilization. Subsequent quiescent usage of the RCS is required for orbit makeup, attitude control, etc.

1.2.5.3 Module Delivery Operations

Based on analyses conducted during this study, the installation of a manipulator on the modular space station was rejected in favor of utilizing the shuttle orbiter manipulation capability. Berthing the orbiter to the station (-X berthing port) provides a stable base for subsequent manipulation of modules into position. The assembly concept is illustrated in Figure 2.1-16.

The modules are launched in an inactive mode. The crew members enter the station cluster while berthed to the shuttle and perform the required subsystem activation and checkout. A typical delivery operations sequence is shown in Figure 1.2-17.

The third module to be delivered is the SM-1, and the activities associated with assembly crew ingress and interface hookup require approximately 3 days from the time of launch (assuming an 8-hour rendezvous time). Two members of the shuttle 4-man crew are used for all assembly activities. The remaining activities of subsystem activation, checkout, and preparation for shuttle departure require an additional 1-1/2 days. Two days remain for contingency operations, deorbit phasing, and landing.

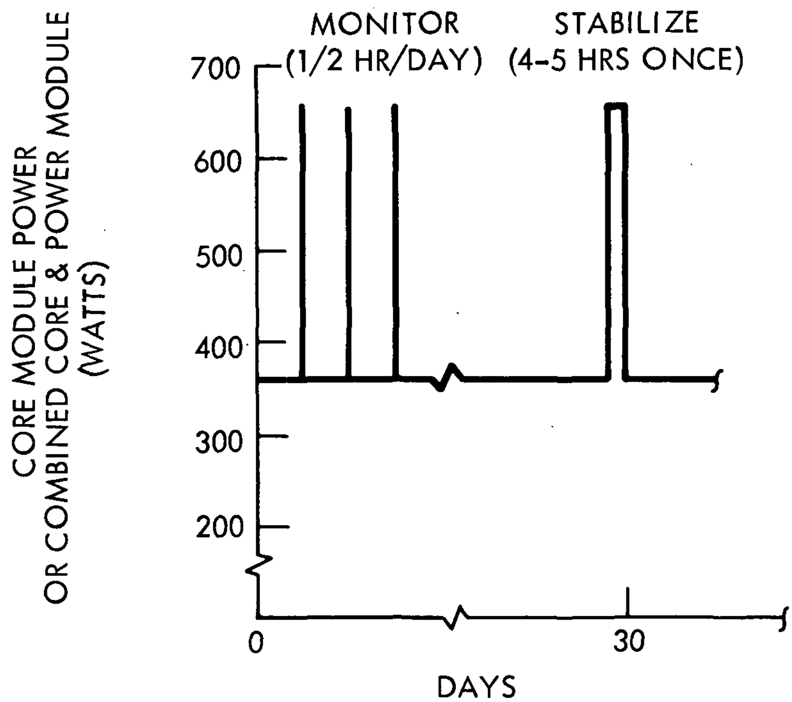


Figure 1.2-13. Buildup Power Requirements

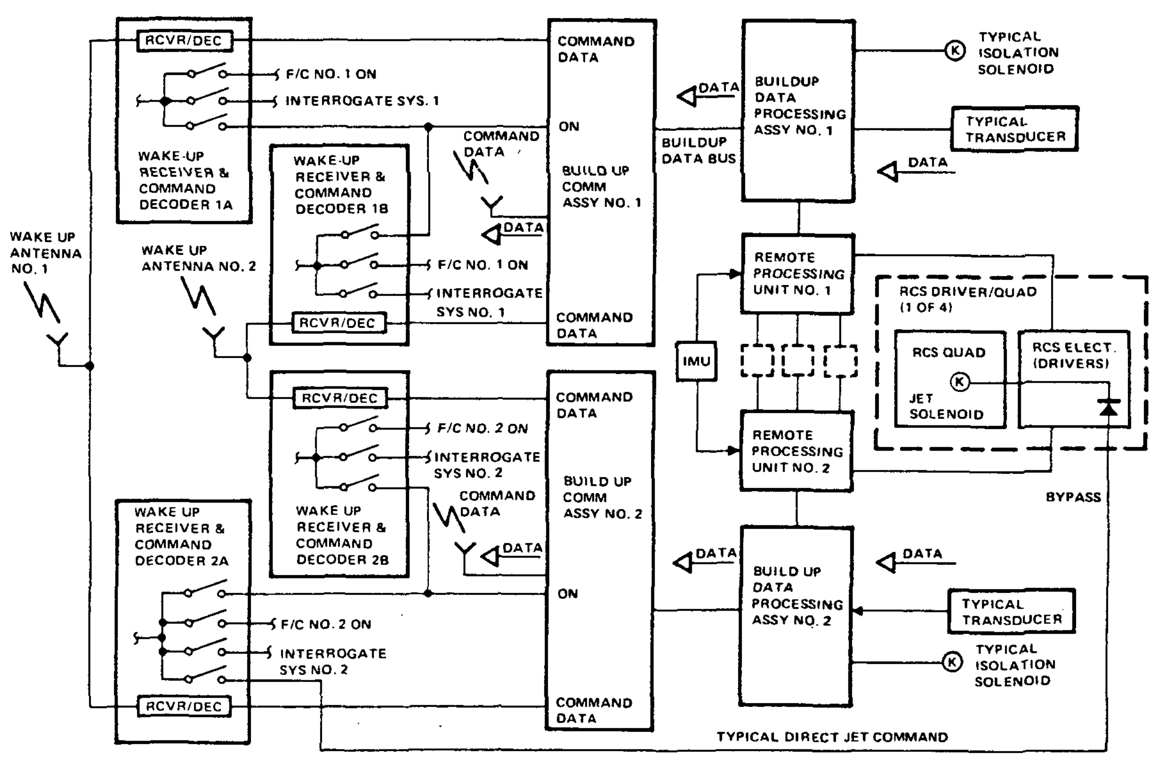


Figure 1.2-14. Buildup Signal Flow

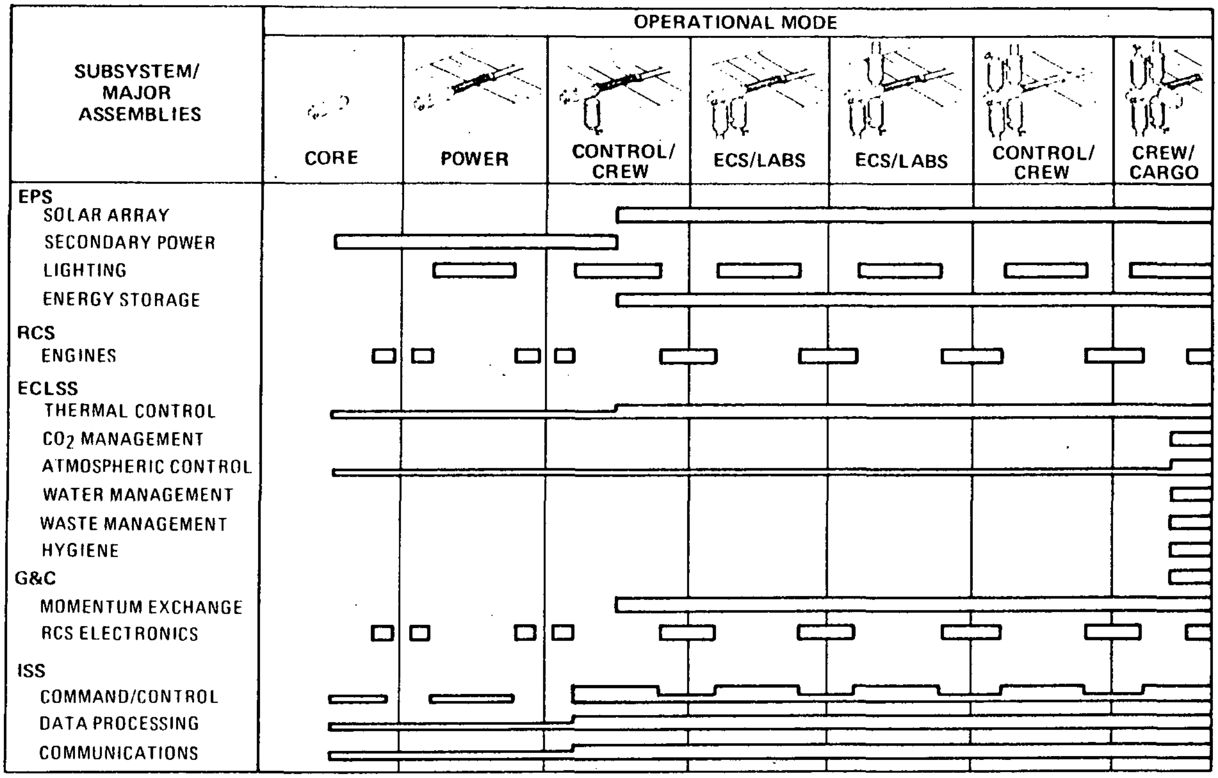


Figure 1.2-15. MSS Activation and Checkout Requirements

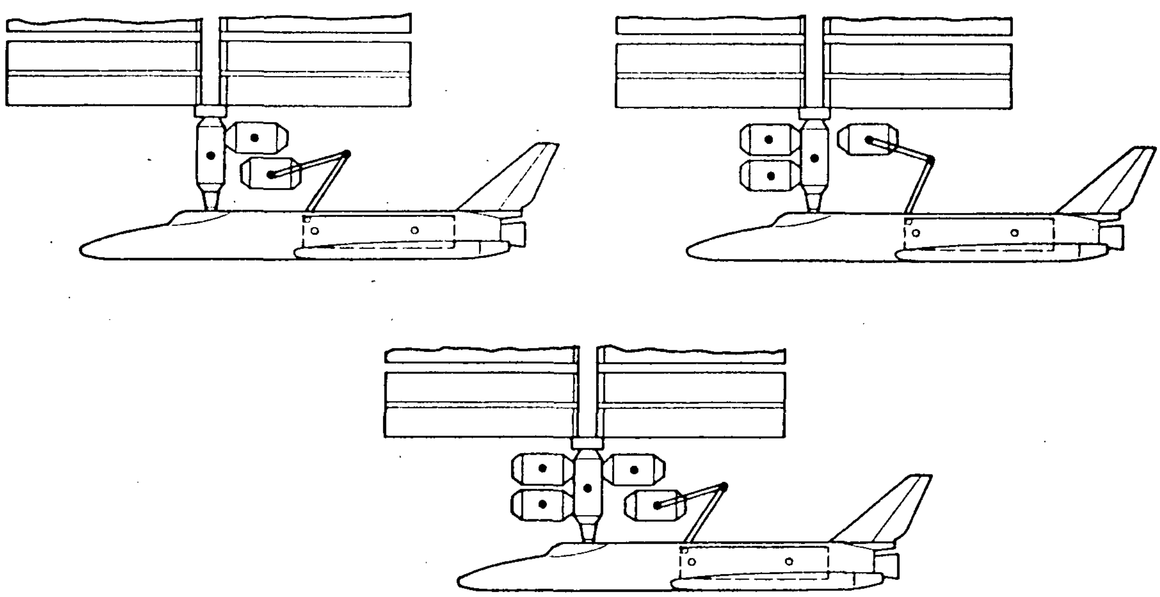


Figure 1.2-16. MSS Assembly Concept

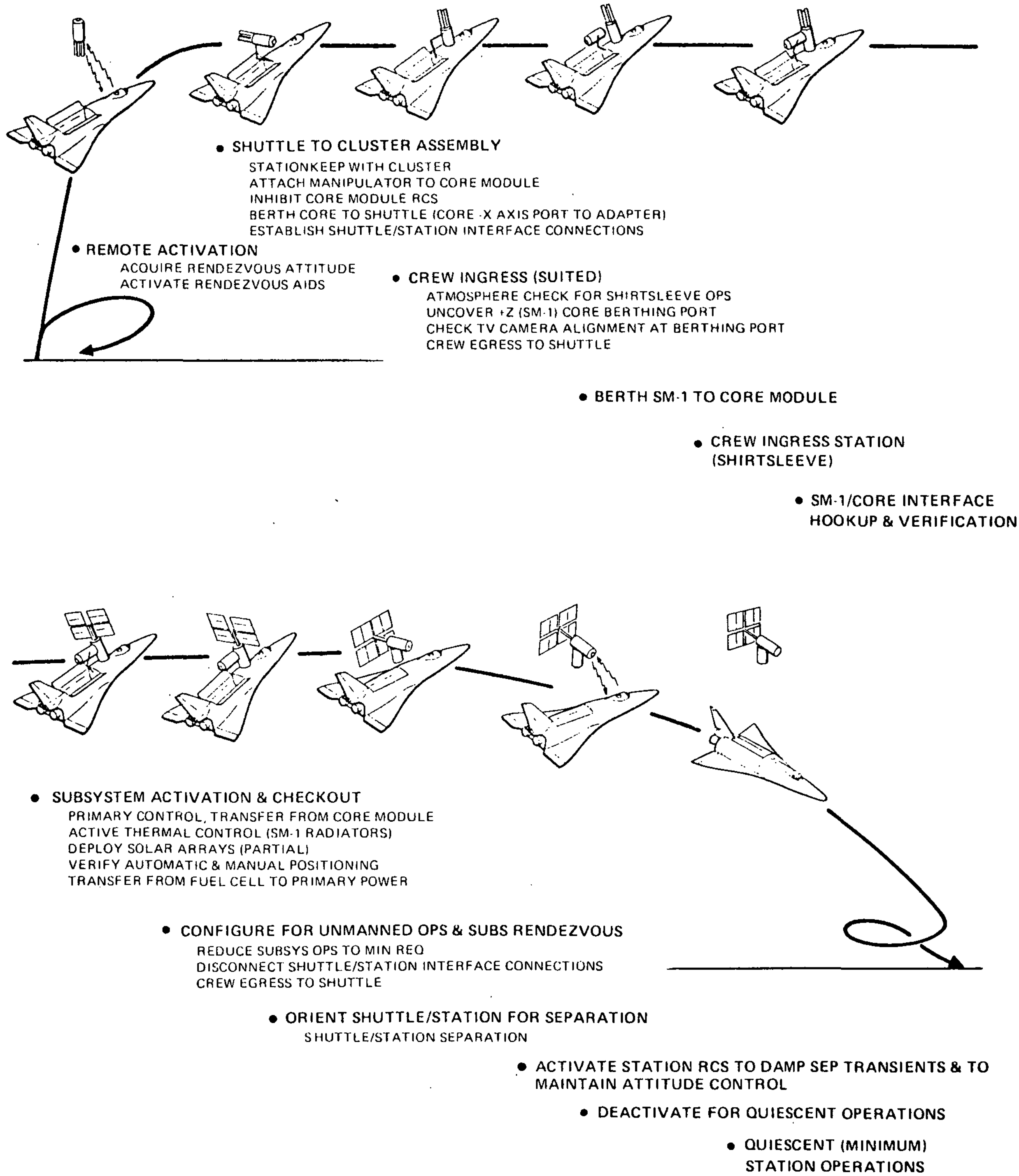


Figure 1.2-17. Typical Delivery Operations Sequence

1.2.6 MSS DEVELOPMENT PLAN

Figure 1.2-18 is a schedule summary of the MSS program. Key milestones and events support the currently established guidelines and constraints.

1.2.7 STATION BUILDUP AND LOGISTICS RESUPPLY

During the buildup and operational phases of the modular space station, periodic resupply of various consumable items are required in order to support both the station operations and the experiment program. The buildup of the station involves the placement in orbit of various modular sections. The configuration is sized for on-orbit operations of 120 days without resupply. As supplies are depleted, replenishment of the consumed items must occur in order to support continued station operation. As defined in the guidelines and constraints, resupply flights by the shuttle can occur at a rate of no less than 30 days. Thus, resupply to the station must ensure continued operation for at least 30 days plus some added margin. Figure 1.2-19 briefly depicts the aforementioned resupply operational philosophy.

The initial launch includes enough supplies for up to 120 days of operation. Many of these supplies will be stored in the cargo module, using it as a pantry.

In addition to shuttle flights for cargo resupply, shuttle flights are required to deliver the modules to the station and deliver the crew to the station.

Affecting the consumable usage rate are three factors: (1) modules and subsystems on orbit, (2) level of manning, and (3) experiment scheduling. The total monthly logistics resupply requirements are derived from the experiment schedule and are combined with the logistics required to support various manning levels of station operation.

Figure 1.2-20 presents a composite schedule of shuttle flights in support of the modular station. Contained in this timeline are shuttle flights for module delivery, crew delivery and rotation, and cargo. A schedule of the operational mode of the station to support the experiments is shown in Figure 1.2-21.

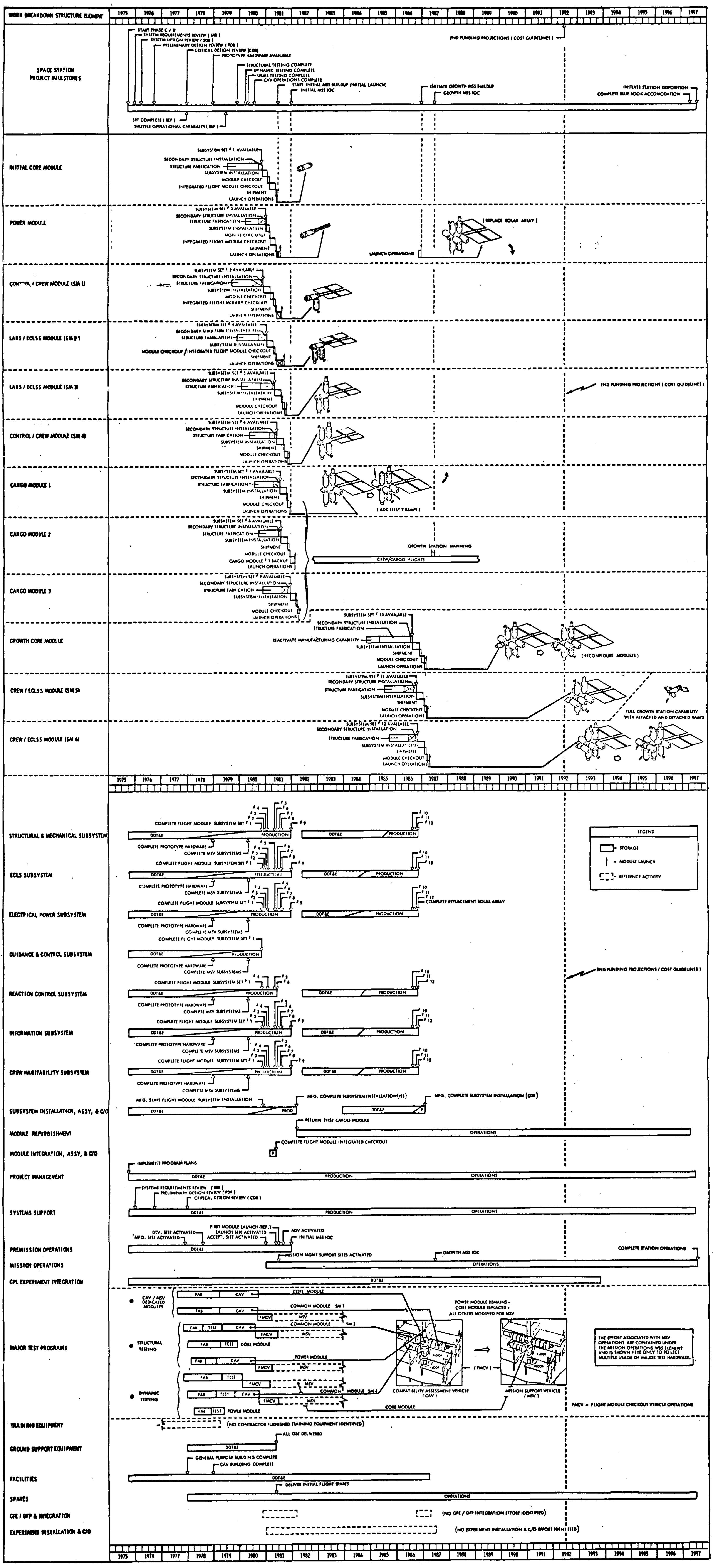


Figure 1.2-18. MSS Master Phasing Chart

Space Division
North American Rockwell

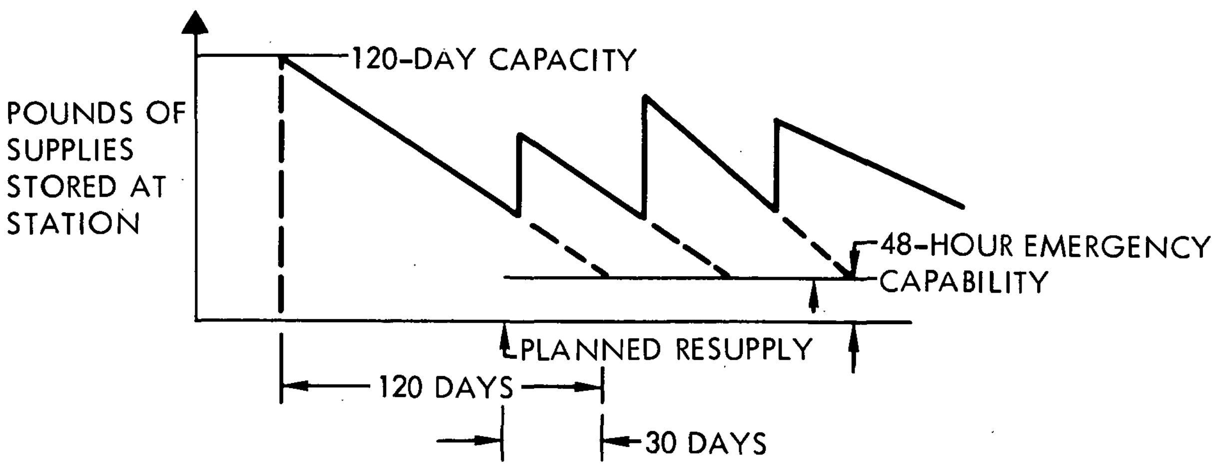


Figure 1.2-19. Resupply Philosophy

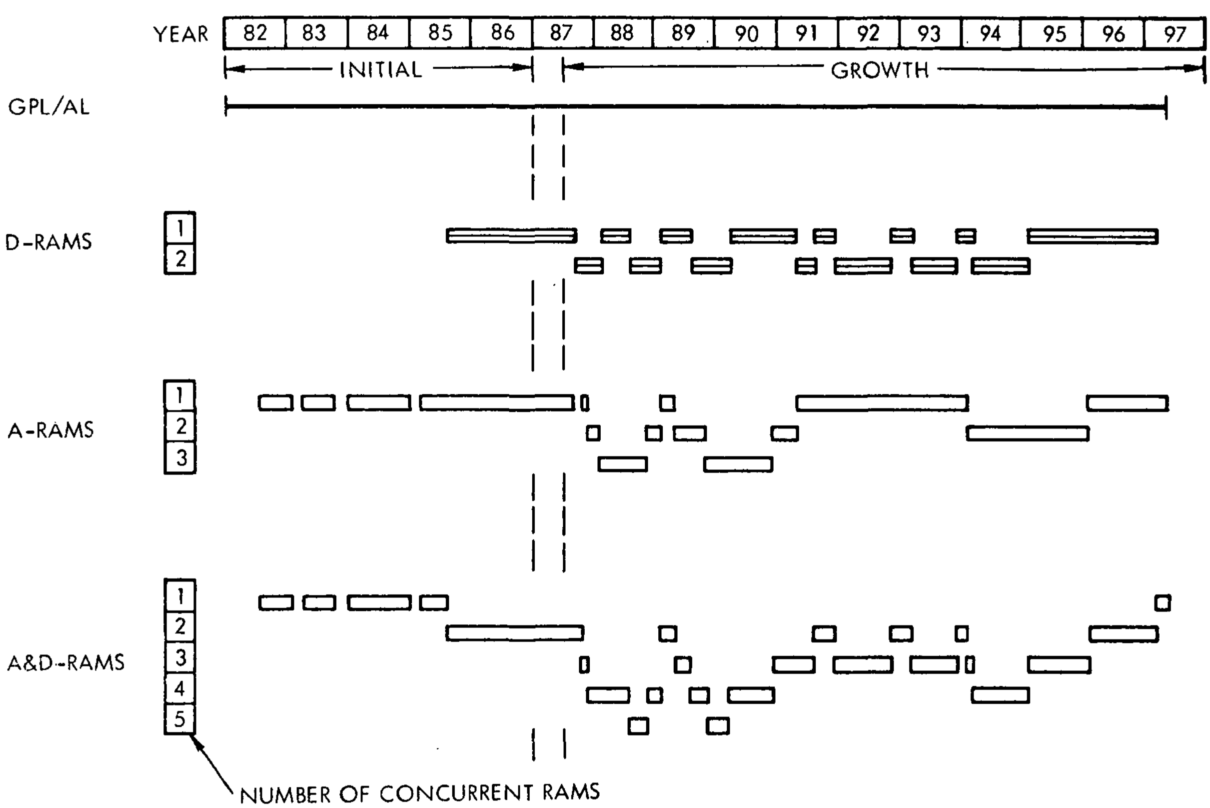
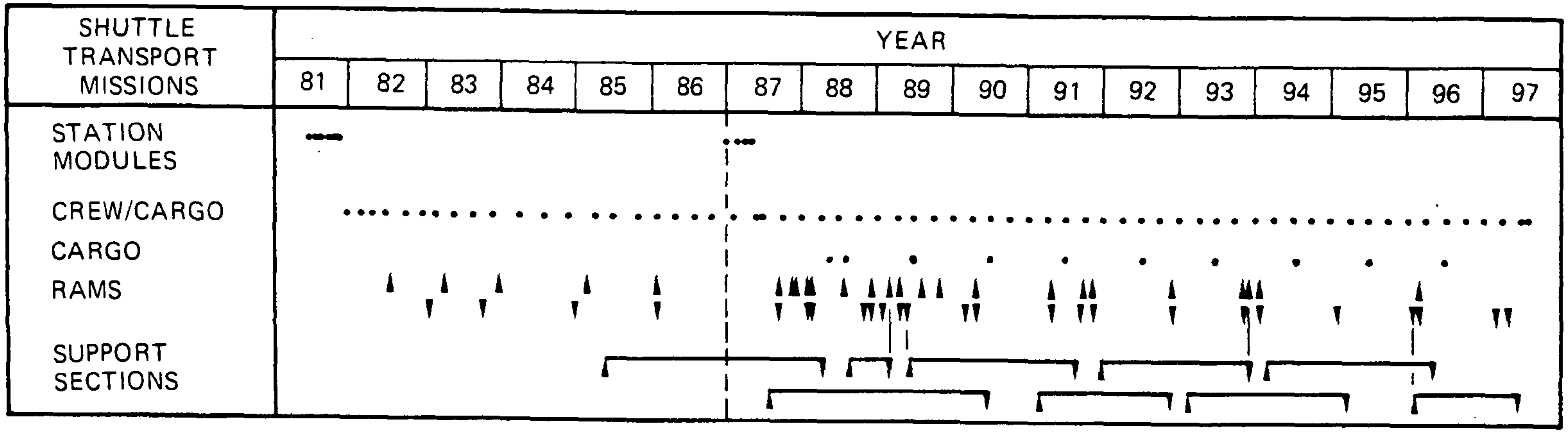
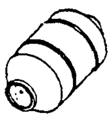


Figure 1.2-20. Shuttle Support Requirements





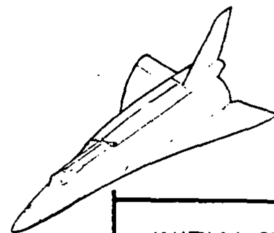
CARGO MODULE CAPABILITY

- ~ 11,800 LB/FLIGHT

CARGO REQUIREMENTS *

- INITIAL STATION - 2884 LB/MO
- GROWTH STATION - 5415 LB/MO

* EXCLUDES UP-DOWN EMERGENCY CARGO



SHUTTLE SUPPORT SUMMARY

INITIAL STATION		
• STATION MODULES	6	35 FLIGHTS (~1/8 WEEKS)
• CREW/CARGO	20	
• RAMS	8	
• SUPPORT SECTIONS	1	
GROWTH STATION		
• STATION MODULES	4	99 FLIGHTS (~1/6 WEEKS)
• CREW & CARGO	54	
• RAMS	24	
• SUPPORT SECTIONS	17	

Figure 1.2-21. Schedule of MSS Operational Modes to Support Experiments

1.3 MISSION SUPPORT VEHICLE

1.3.1 MSV CONCEPT

A mission support vehicle will be developed as an integral part of the MSS program. The MSV will be a flight-configured tool that will be used to support development and test activities for flight station modules, cargo modules, experiment modules, spares, and modifications. The MSV also will serve as a familiarization tool for crew and passengers prior to their tour of duty in the orbiting MSS.

Development of this vehicle will be phased to effectively utilize structures and systems developed for other major test articles. Eventually, flight systems will be installed to enhance the utility of the MSV as a ground test tool for the operational MSS.

Initially, the MSV modules will be located at the module manufacturing site where they will be used for acceptance checkout of the first four initial station flight modules. As each of the flight modules to be acceptance-tested is added to the acceptance fixture, the corresponding module is removed and shipped to the launch and operational support site where it will be activated and maintained in operational configuration during the life cycle of the MSS. Final acceptance and configuration verification of the remaining three initial station modules, the RAM's and buildup MSS modules will be performed at the launch/operational support site.

1.3.2 CONFIGURATION

The MSV consists of five modules: a core module, the two control center station modules, a crew quarter representative module, and a power boom.

In its operations support form, the MSV will be configured as close as possible to the MSS flight configuration. One major difference is the lack of the solar arrays as the power source. These will be simulated by the appropriate GSE. Other differences are discussed in the following paragraphs.

1.3.2.1 Core Module

The MSV core module will utilize the primary and secondary structures first used in the dynamic testing program. Prototype subsystems will be installed for the completion of compatibility assessment testing and will be updated to flight qualified hardware for use as an acceptance fixture for flight modules. When its role as an acceptance test is completed, the MSV core module will be shipped to KSC.

1.3.2.2 Station Module 1

Station module 1 for the MSV will evolve from a module first fabricated for use in the compatibility assessment vehicle (CAV). During this first utilization phase, the module will serve to assess subsystems in their prototype configuration.

During its next phase, this module will have flight subsystems installed and will be used as part of the flight modules checkout vehicle (FMCV) for the initial station. It should be noted that this module will remain with the FMCV until the flight core module is singly checked out and the flight SM-1 is delivered to the FMCV. At this point the FMCV SM-1 will be shipped to the MSV site.

1.3.2.3 Station Module 3

Station module 3 for the MSV, like the other MSV modules, will be used for various other applications before it is finally configured and used as part of the MSV.

Its first use will be as a structural test unit followed by subsystem installation and use as part of the CAV; in this capacity it will be used to verify not only the systems assigned to SM-3 in the flight module but also to verify the systems assigned to SM-2. The rationale is that the number of active systems in SM-2 is not sufficiently different or complex to warrant a complete duplication for CAV applications.

The same rationale is pursued during the use of this module in the flight modules checkout vehicle and later in the MSV. SM-3 will be retained as part of the FMCV until both SM-2 and SM-3 for the flight vehicle have been checked out. FMCV SM-3 will then be shipped to the MSV site to be used as part of this vehicle.

1.3.2.4 Station Module 4

Station module 4 is basically a second control center similar in design and function to SM-1. This module will be used in dynamic testing and during CAV activities. The CAV function is to satisfy the requirements associated with providing the two isolatable volumes in the operational MSS. One of its principal uses will be to verify the software required to operate in a multi-computer, multiprocessor environment. For example, tests will need to be performed with dual control centers to develop and verify the capability to transfer command control from one isolatable volume to the other.

1.3.2.5 Power Boom

The MSV will be designed and fabricated to utilize flight-qualified subsystems. One significant exception is the power module. The flight version of this module utilizes solar arrays as the power source. Utilization of the arrays in the MSV will not be attempted; instead, the power boom will be installed to verify its interfaces with the core module, and ground support equipment will be utilized to simulate the output of the solar array.

1.3.3 INTERFACES

The MSV will be located in the MSOB at KSC during its operational life in support of the orbiting MSS. It is to be largely self-sufficient and will have few physical interfaces. The major areas of concern are discussed in the following paragraphs.

1.3.3.1 Installation

The MSV will be installed in the MSOB. Floors on the core and station modules will be perpendicular to the core module cylinder walls. This configuration establishes the requirement for "standing up" the MSV on the core module cylinder end. Other configuration and operational requirements that govern the installation facility characteristics are the length of the assembled MSV and the requirement for being able to mate SM's, cargo modules, and RAM's to the various docking ports. Solutions to these problems are discussed in Section 3.0.

1.3.3.2 Controls and Communications

The MSV will include two control centers corresponding to the orbiting station SM-1 and SM-4 modules. These control centers will include the control consoles and data processors as well as their associated data storage devices and the data busses required to control the MSV systems as well as those modules attached to the MSV for compatibility verification and checkout.

The MSV also will include the external and internal communications systems that will be designed into the MSS. Interfaces between the MSS ISS and the facility will be required for both of these systems for operational use.

Physical access to the on-board monitoring systems and displays will be restricted because of space limitations in the MSV. Off-board monitoring and displays will be provided through ground universal test equipment (UTE) hardwires to the data bus and through connections to the MSV RF data links. Audio communications also shall be provided by connecting the internal communications system to the facility operational intercommunications system (OIS).

1.3.3.3 Electrical Power

MSV power will be supplied by GSE through the wiring normally used by the solar arrays. This GSE shall be capable of duplicating the characteristics of solar array power output under varying load conditions. The power boom, itself, will be in place and will provide the actual interface between the GSE and the MSS.

1.3.3.4 Facilities

The MSS is designed to operate in the extreme environment of earth orbit and will utilize environment and thermal control systems suited for this purpose. These same systems will be used for the MSV whenever possible, but ground cooling systems will be required to supplement the flight systems during MSV operations on the ground.

1.4 SPACE SHUTTLE SYSTEM

The space shuttle system referred to in this report is the two-recoverable stage vehicle. It is composed of a booster and orbiter, both of which are capable of returning to earth for reuse. It is designed to be a low-cost multipurpose system that will replace the existing nonrecoverable launch vehicles.

The shuttle is to be used both by the NASA and the DOD. The DOD has established a requirement for a cross-range cruise capability of approximately 1100 nautical miles. The propulsion systems for the boost and orbit phases for both the booster and orbiter are the LO_2/LH_2 rocket engines; the orbiter engines do not operate until after the orbiter has separated from the booster. Air-breathing JP-1 jet engines may be installed on both the booster and orbiter to permit the booster to return and land at the launch site, provide the orbiter with the required cross-range capability, and to be used for horizontal flight test and ferry flight between sites. The air-breathing engines on the orbiter may be deleted for some missions involving north-south polar orbits and payload maximization.

1.4.1 SPACE SHUTTLE PROGRAM

As a program objective, schedule planning is designed to minimize the design development test and evaluation (DDT&E) cost to support the first manned orbital flight planned to occur in April 1978. Shuttle program requirements will consist of the following major articles:

1. Five orbiter and four booster flight vehicles
2. An orbiter and booster structural test article
3. An orbiter and booster main propulsion cluster development test article

To support the manned orbital flight date noted previously, the major milestones in the program are as follows:

1. Start Phase C/D in March 1972
2. Complete preliminary design review (PDR) in May 1973

3. Complete critical design review (CDR) and 95-percent engineering release in December 1974.

Completion of prelaunch operations for all of the vehicles is as follows:

June 1976 (first horizontal flight)

April 1978 (first manned orbital flight)

Mid-1979 (shuttle will be operational)

1979-1987 NASA/DOD operations

The operational phase of the shuttle program is based on a 445-flight traffic model spanning the years from 1978 to 1987. The 445-flight traffic model is used to establish operations requirements, schedules, and cost estimates. Of these 445 flights, 70 are presently allocated to space station support.

The space station logistics mission comprises routine resupply of cargo, rotation of crews and passengers, and the delivery of functional program elements (FPE) experiment modules to the station. The shuttle will rendezvous and berth (using one of its two manipulators) with the space station located in a 55-degree inclination, 270-nautical-mile circular orbit. The manipulator arms are used to deploy and retrieve these modules. The manipulator is operated by one of the cargo specialists in the orbiter. For these missions, two crewmen plus two cargo specialists are assumed to be in the orbiter.

At the completion of the rendezvous maneuver, the orbiter is within 1000 feet of the space station and maintains this position until the final approach and berthing maneuvers are carried out. The orbiter controls its range and location during this time. The orbiter will be responsible for command and control during the rendezvous and berthing with two-way duplex voice communication is provided between the orbiter and the space station. The orbiter will be capable of transmitting and receiving data from the space station. Both orbiter and space station will have external lighting to aid in rendezvous, station-keeping, and berthing.

1.4.2 CONFIGURATION BASELINE

Because the space shuttle design had not been formalized at the time this report was prepared, a model has been selected for the purpose of this study. The data wire obtained primarily from the Space Shuttle Phase B 180-day review, SV71-4, dated 13 January 1971, and updated to reflect the new requirements resulting from the NASA Manned Space Flight Management Council Meeting, Williamsburg, Virginia, 19-20 January, 1971.

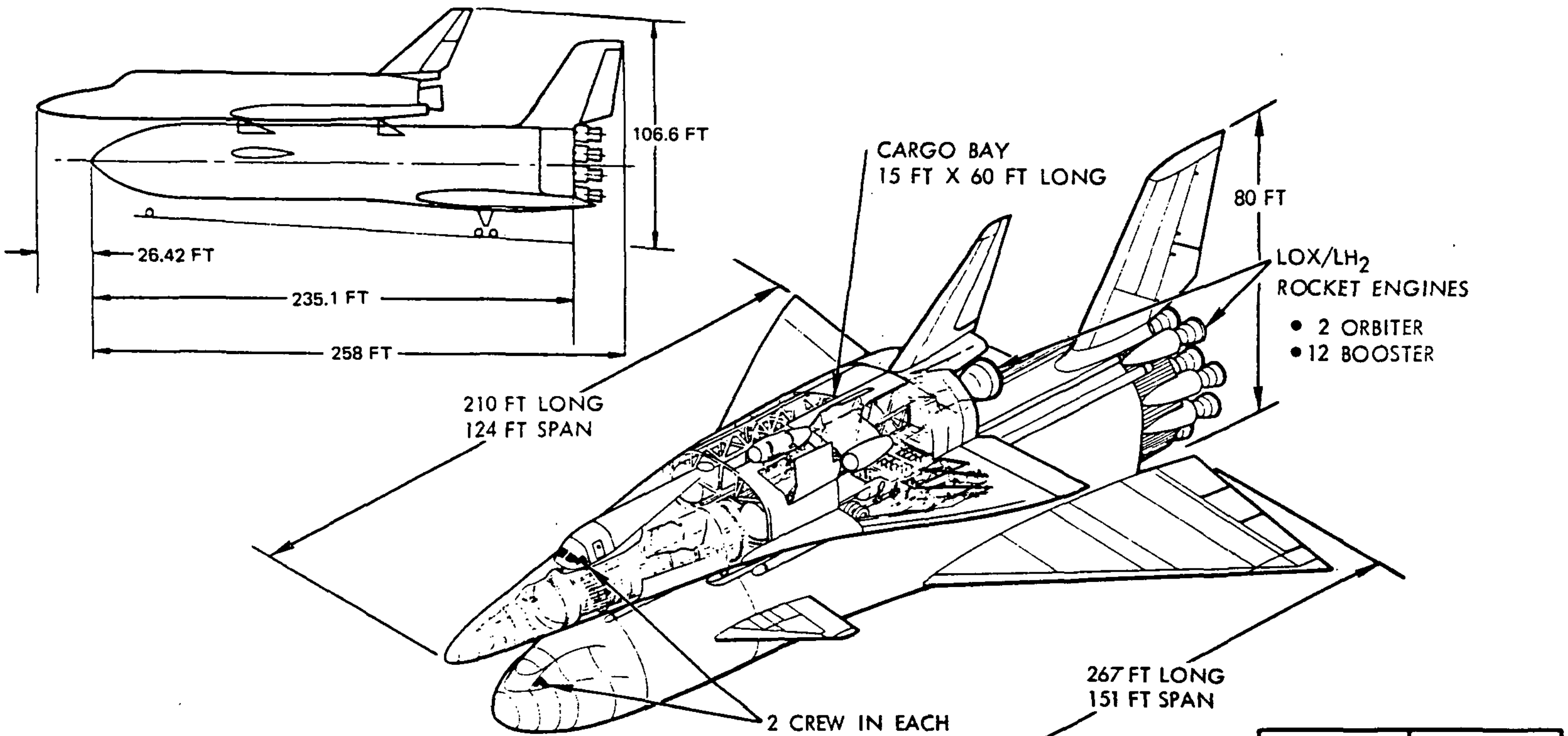
The mated booster and orbiter are shown in Figure 1.4-1. The cargo bay is sized to have a clear volume 15 feet in diameter and 60 feet in length. The vehicle payload weight without the air-breathing engine system (ABES) on the orbiter is baselined to be 65,000 pounds into the easterly (28-1/2-degree inclination) design reference orbit (100-nm due-east launch) or 40,000 pounds into polar orbit. The payload for the space station mission (270-nm - 55-degree inclination) with the ABES installed is established at 25,000 pounds. The c. g. band for the space station payload is shown in Figure 1.4-2.

The flight compartment shown in Figure 1.4-3 accommodates a crew of two plus two additional crewmen/passengers. The two crew/passenger seats are considered to be available for shuttle flights dedicated to space station missions. The two crew/passenger seats shall be considered to be available for crewmen to perform unique space station operations such as buildup and assembly of the modular space station. For multimission shuttle flights, the two crew/passenger seats cannot be assumed to be available for space station personnel, and all such personnel must be accommodated in a cargo/passenger module in the cargo bay after initial orbit insertion. All crew members and passengers will occupy seats in the orbiter during boost entry and landing.

Both the orbiter and the booster wings are delta-shaped. The span of the wings of the booster is 143.5 feet, and the height from the ground to the top of the vertical stabilizer is 80 feet. The booster fuselage length is 255.6 feet. The orbiter length is 181.5 feet, and the wingspan is 106.6 feet.

1.4.3 DOCKING/BERTHING AND PAYLOAD MANIPULATOR

The shuttle orbiter planning currently envisions the use of a manipulator to perform orbiter-to-station berthing and the deployment/retrieval of payloads. Relative motions of 0.05 feet per second or less between approaching vehicles during coupling is defined as berthing; motion greater than 0.05 feet per second, with either vehicle in powered flight, is defined as docking. The space station berthing parts are designed for berthing operations rather than docking. Direct docking to the module can be performed by the shuttle if the module docking interface has attenuators. Attachment of the orbiter to the space station elements and emplacement of additional modules to the station normally will be accomplished through berthing as defined previously. One such concept is illustrated in Figure 1.4-4. Its operation is described in the following paragraphs.



	BOOSTER	ORBITER
TOTAL WEIGHT (LB)	3,889,000	935,740
ASCENT PROPELLANT (LB)	3,114,000	604,500
ON-ORBIT PROPELLANT (LB)	-	31,867
ENTRY WEIGHT (LB)	744,356	282,052
LANDING WEIGHT (LB)	633,019	276,115
STAGING VELOCITY (REL) (FPS)	10,127	-
STAGING (REL) (DEG)	5.95	--
STAGING q (PSF)	14.69	-
FLYBACK RANGE (N MI)	316.5	-
MIN ISP (VAC)	436	456
NOM ISP (VAC)	439	459

THRUST PER ENGINE (LB) - 540,000 SL (BOOSTER)
- 620,000 VAC (ORBITER)
EXPANSION RATIO - BOOSTER -35:1; ORBITER - 150:1

Figure 1.4-1. Shuttle Baseline

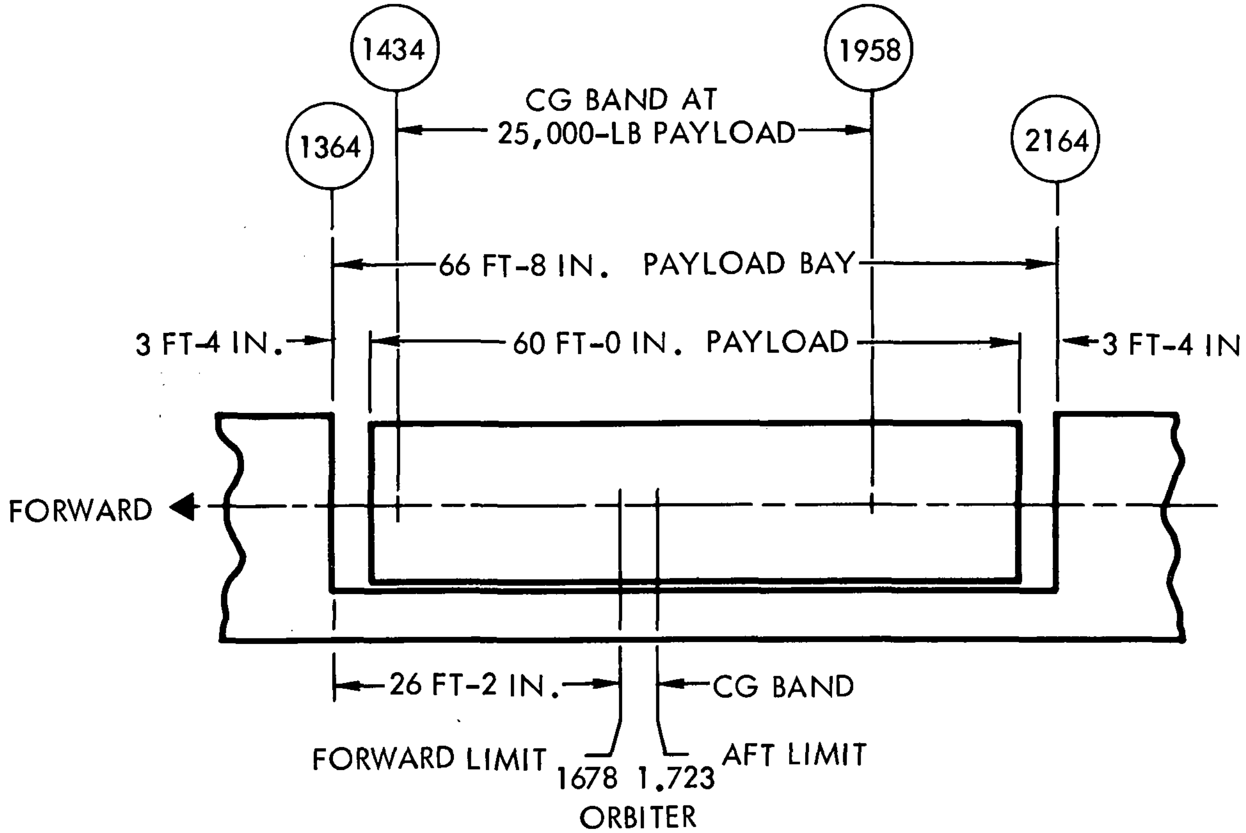


Figure 1.4-2. Payload Dimensional Data

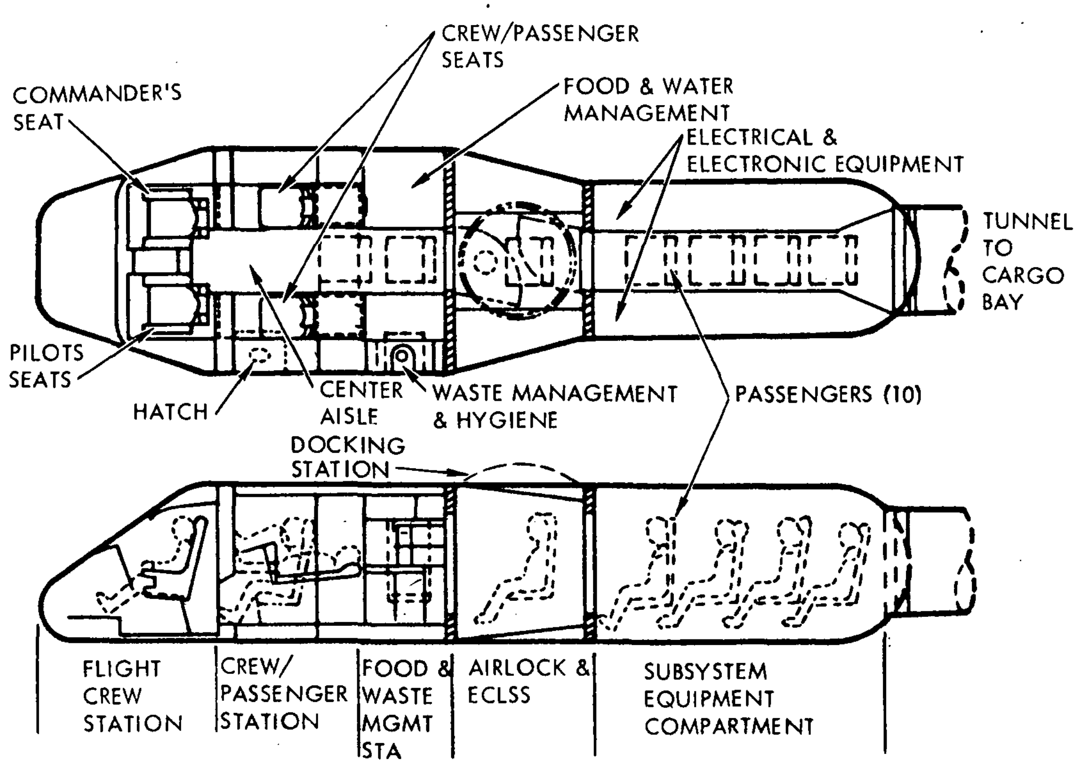


Figure 1.4-3. Flight Personnel Compartment—Passenger Configuration/ Rapid Egress

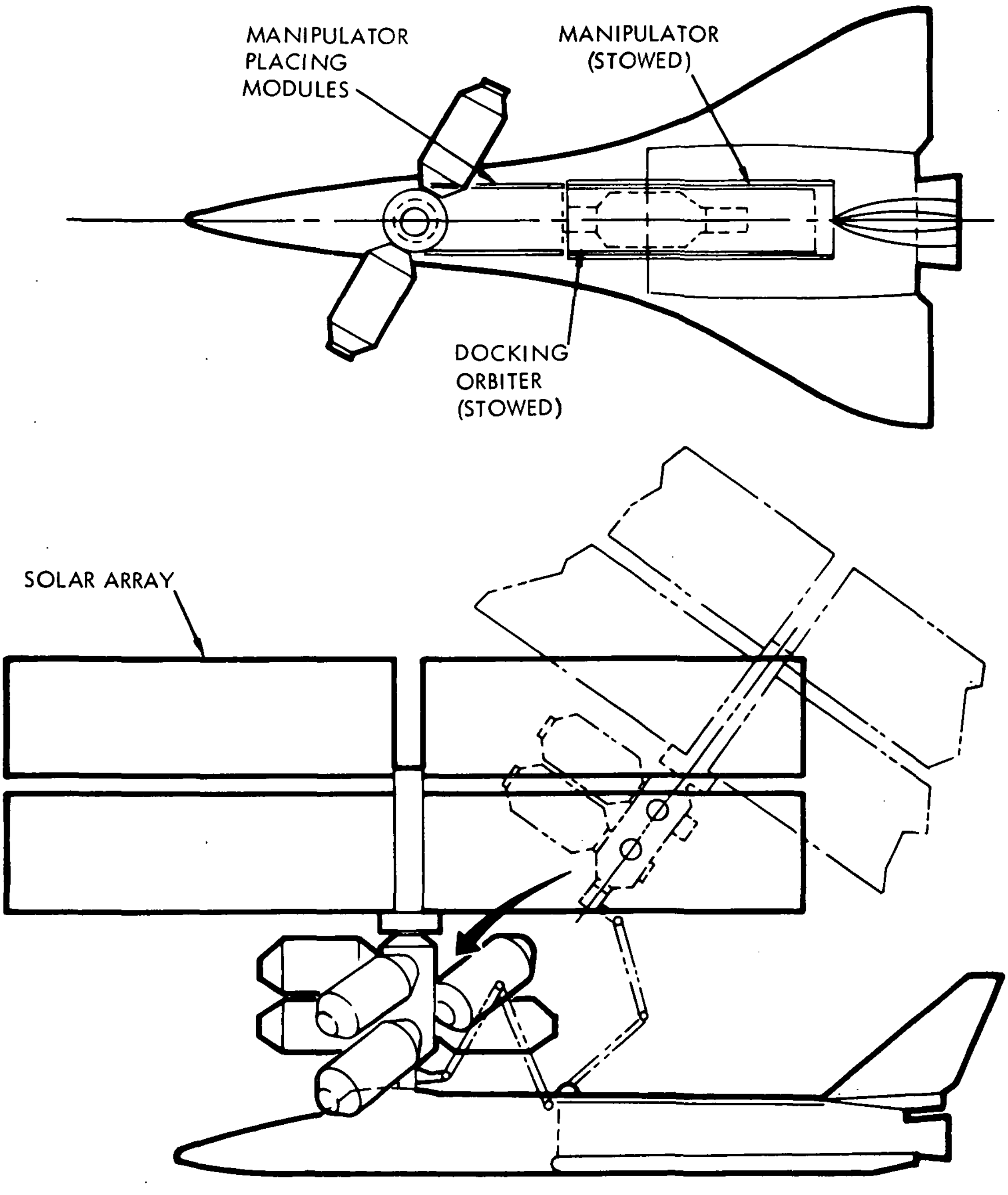


Figure 1.4-4. Orbiter-Based Manipulator

1.4.3.1 Berthing

In its standoff position, the orbiter manipulator removes a cylindrical berthing adapter from the payload bay and attaches it to the orbiter berthing port. This adapter is a transitional element to accommodate the 60-inch-diameter station berthing port at one end and the orbiter's 40-inch-diameter hatch on the other. This adapter is payload-supplied.

The manipulator then draws the two vehicles together. The adapter engages the space station berthing port and completes the berthing. At this point the crews can transfer from the orbiter into the station through the adapter.

1.4.3.2 Payload Deployment/Retrieval

After the two vehicles are connected, the manipulator is disengaged from the adapter and is attached to the payload module. The payload module is withdrawn from the payload bay and maneuvered to its berthing port on the station, and berthing is accomplished. Payload retrieval is the reverse of the deployment sequence.

1.4.4 GROUND OPERATIONS PROCESSING CONCEPT

For the purpose of this study, it is assumed the Saturn V concept of vertical transportation from the checkout facility to the launch pad of integrated vehicles will be implemented for the shuttle, because it has the potential of requiring minimum investment in new facilities.

1.4.4.1 Operations

The baseline operational cycle of the reusable space shuttle from launch-to-launch is shown in Figure 1.4-5. During normal operations, the vertically launched booster upon completion of its mission will return to its launch site within minutes of launch. The operational control will shift from launch control to landing control. After a conventional type landing, the vehicle will be towed to a safing and deservicing area where it will be rendered safe prior to entering the maintenance and checkout facility. The orbiter, upon completion of its mission, will return to the launch site and, upon landing, will be taken to the safing and deservicing area. Upon completion of safing and deservicing, the vehicle will be transported to the maintenance and checkout facility to undergo critical inspections and nondestructive tests. The extent of refurbishment, beyond routine maintenance, will depend upon the results of the inspection and tests. After refurbishment, the individual stages will be subjected to systems checkout and transferred to the maintenance and checkout facility (MCF). Cargo will be loaded into the orbiter prior to transfer to the launch pad.

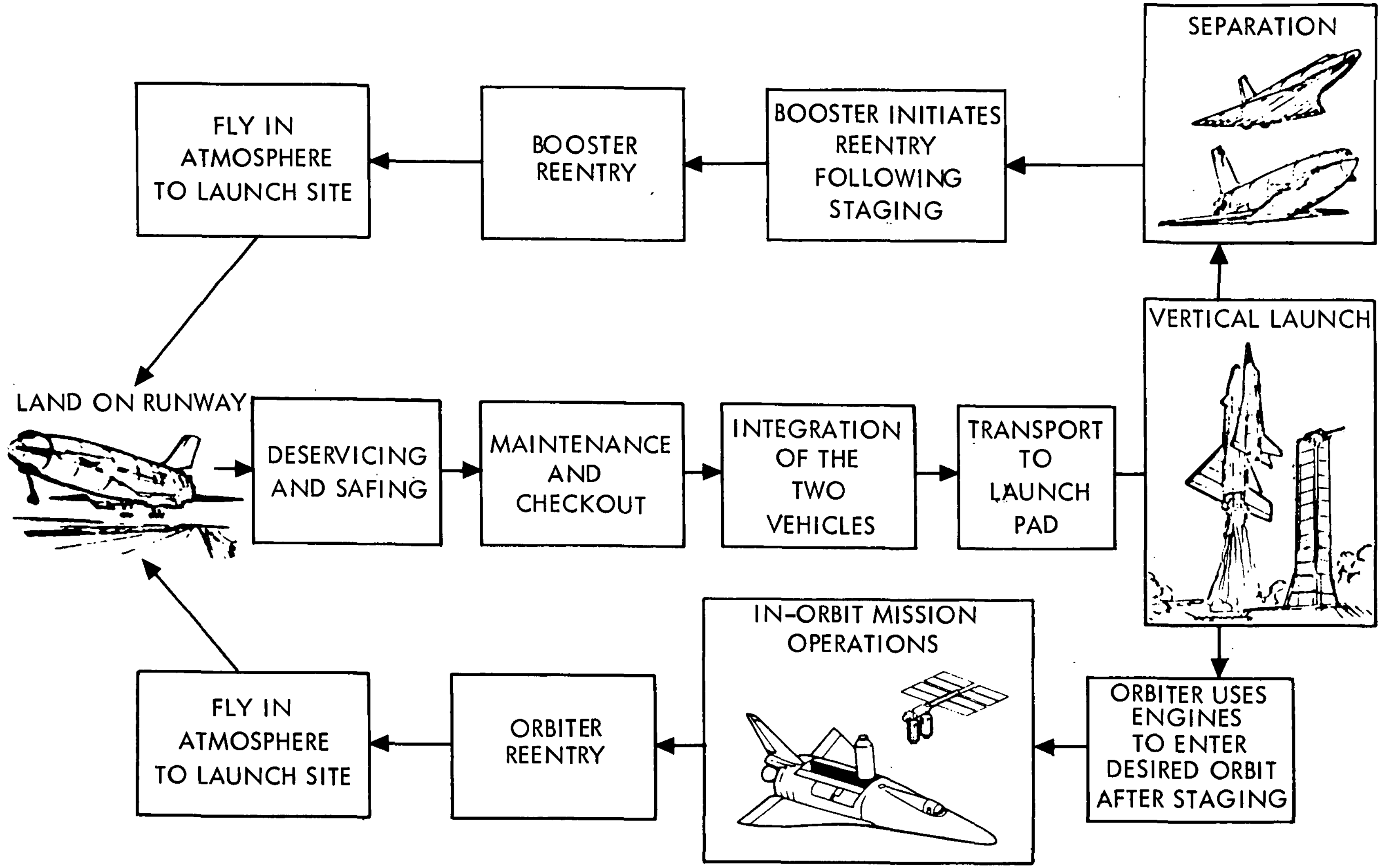


Figure 1.4-5. Space Shuttle Baseline Operational Cycle

Vertical integration will take place in a high-bay cell on a mobile launcher. Upon completion of a mate and post-mate checkout, the mated vehicle and the launcher will be transferred to the launch pad by crawler-transporter. Upon completion of on-pad checkout, propellant loading and passenger and crew ingress, the vehicle will be ready for launch. The shuttle facilities at KSC common to MSS are illustrated in Figure 1.4-6. The ground operations flow and countdown are presented in Figure 1.4-7.

1.4.5 SHUTTLE FACILITY REQUIREMENTS

It is assumed that KSC will be the operational site for the space shuttle. The concept utilizes existing facilities whenever they were considered technically and economically feasible.

The shuttle facility requirements to support ground operations were extracted from North American Rockwell Space Shuttle documentation and evaluated with reference to space station operations. The major requirements are summarized as follows:

1. Payload preparation area. Payloads may contain as many as seven payload units and may include cryogenic propellants, storable propellants, gases, and radioactive materials. The main preparation area should contain at least 32,000 square feet and should be controlled to class 100,000 clean conditions. A 30-ton service crane also should be available. Separate remotely located buildings are required for hazardous propellants, pyrotechnics, and radioactive materials.

2. Erecting, mating, and transporting facilities. The site must provide facilities to accomplish these tasks and place the mated vehicles on the launch pad.

3. Launch complex. Two launch pads are required to support the planned launch rate. Each pad requires storage and loading facilities for 1.8 million gallons of LH_2, 1.2 million gallons of LO_2, and 35,000 gallons of JP fuel. Pressurant and purge gas systems as well as utility supplies are required. A launch control center with tracking, communications, range safety, and related systems must be provided.

4. Landing facility. Returning vehicles require a landing facility at the operating site. The runway should be 200 feet wide, 10,000 feet long, and capable of withstanding a booster landing weight of 650,000 pounds on twin-tandem gear. A control tower and landing, communication, and tracking systems are required.

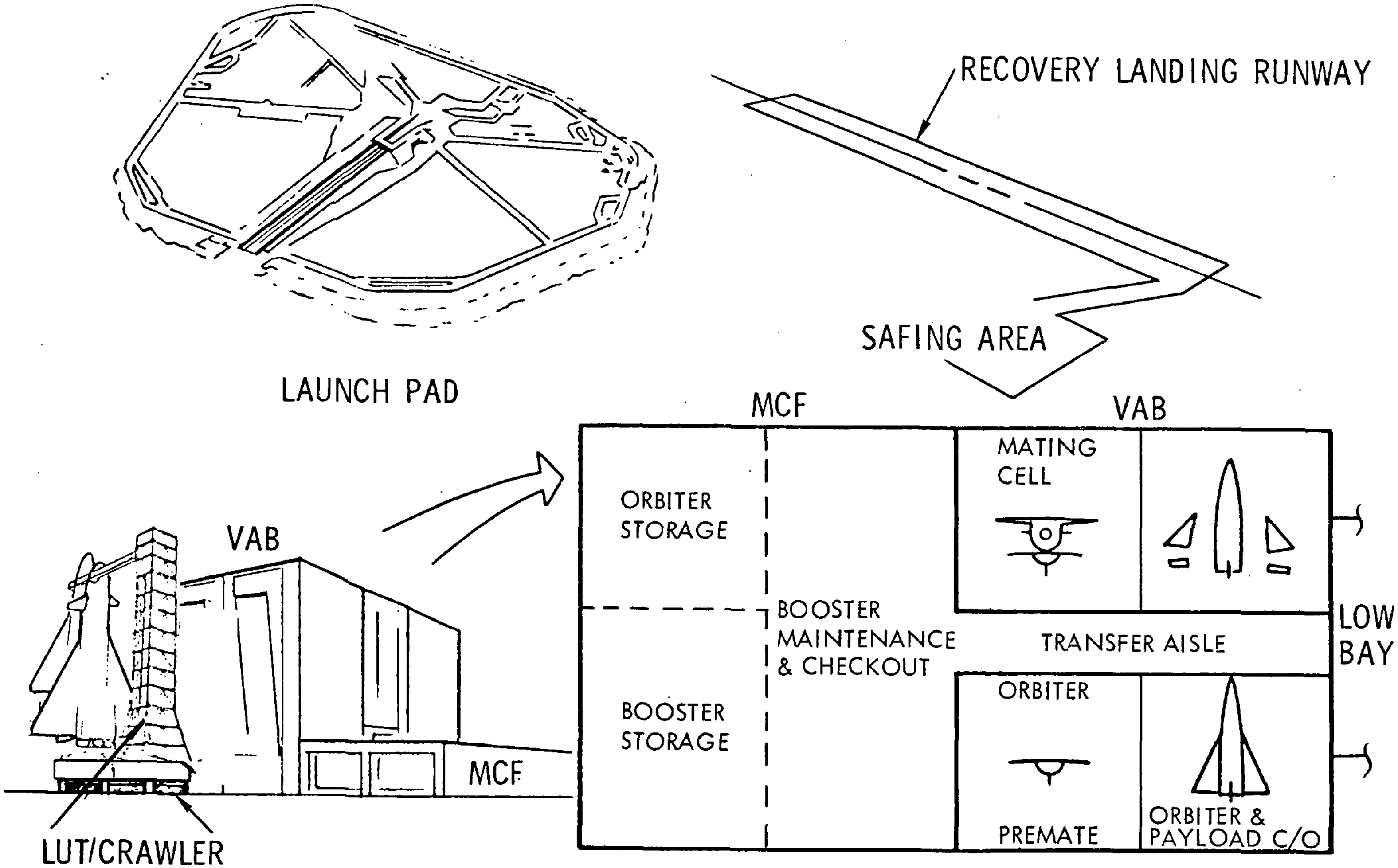


Figure 1.4-6. Shuttle Facilities Common to MSS

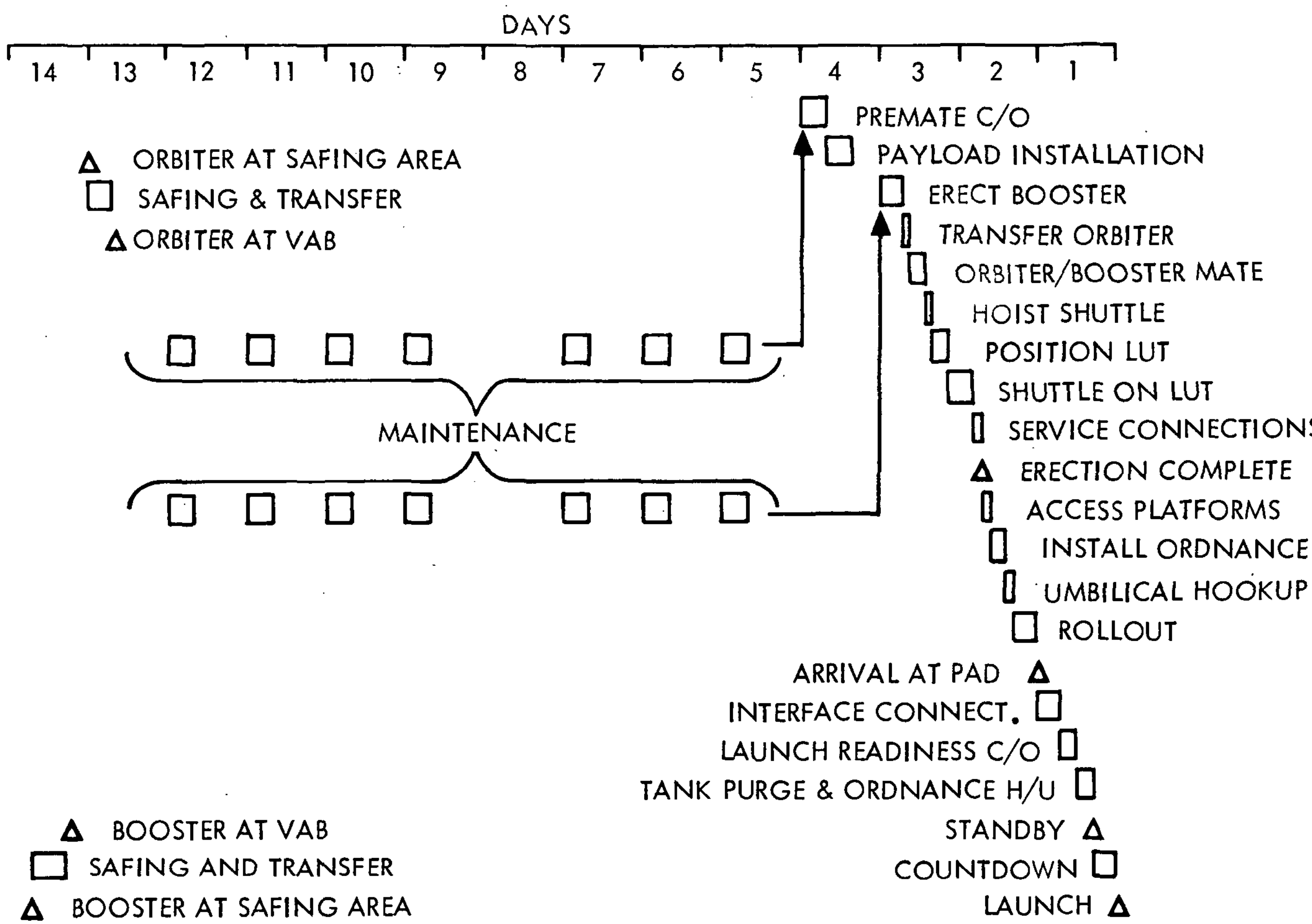


Figure 1.4-7. Shuttle Flow

5. Safing facility. A safing facility is required to receive the booster and orbiter after landing, remove crews and passengers, remove payloads, drain and dispose residual propellants, purge the tanks, remove or safe pyrotechnic devices, and prepare the vehicles for towing to the maintenance and checkout facility.

6. Maintenance and Checkout Building. Support of the planned launch rate requires two maintenance and checkout stations for the booster and two for the orbiter. Booster checkout and maintenance requires an area 220 feet wide and 640 feet long with a 120-foot-clear height over the vertical stabilizer and a 70-foot-clear height in the remaining area. The orbiter requires a 170-foot by 510-foot area with an 80-foot-clear height.

7. Storage facility. Storage space is required for all vehicles. The maintenance and checkout facility can store four vehicles; however, additional space is required for two boosters and three orbiters.

8. Support activities. Included among the numerous support activities required at the operations site are shops, laboratories, training facilities, office areas, and crew and passenger quarters.

1.4.6 MSS/SHUTTLE COMMON FACILITY USE

1.4.6.1 Shuttle Orbiter Mating Facility

Following a study of erecting and mating alternatives, it was concluded that the space shuttle vehicles should be erected to the vertical position, placed on a mobile launcher in the VAB, and mated as shown in Figure 1.4-6, using one high bay cell of the existing VAB. To meet these handling requirements, the following modifications would have to be made to the high bay cell:

1. A second 250-ton crane must be added, supported by the existing rails at the top of the bay. An alternative approach is the addition of a 250-ton movable counterbalance, which would permit splitting of the load and erection with the existing crane.

2. Two paneled exterior sliding doors adjacent to the vertical lift doors must be removed to a height of 100 feet and a width of 40 feet. Two new horizontal-sliding, motor-operated doors must be provided to cover this area. This modification is required to provide vehicle wing clearance as the vehicle is removed from the cell on the mobile launcher.

3. The jib crane at the 80-foot elevation and extension platforms U through X must be removed.

4. Some utility redistribution will be required to serve this activity and the support equipment involved.

1.4.6.2 Shuttle Launcher

The shuttle will utilize a modified version of the Apollo program technique of vertical stacking and transportation to the pad from the VAB. It is planned that three existing Saturn mobile launchers will be required which must be modified as follows:

1. The upper portion of the launcher above the 320-foot level will be removed.

2. New swing arms with 100-pound-per-square-foot live load capacity and designed to match shuttle vehicle configurations will be installed for crew, passenger, and payload access. Crew and passenger access arms should be capable of moving from the retracted position to the vehicle interface position in about 6 seconds for emergency egress.

3. Semifreefall elevators from the crew and passenger egress arms to a safe area in the launch pad will be added.

4. A set of rise-off disconnect arms will be installed.

5. The flame opening will be modified to accept the new launch pedestal base structure.

6. Reoutfitting of systems to support the mated shuttle vehicles will include installation of a leak-detection and warning system and fire-suppression and water-deluge equipment.

7. New propellant ducting will be installed.

8. A damper arm to the booster vehicle will be installed. Figure 1.4-8 is a sketch of the modified mobile launcher.

The existing crawlers and crawlerway will be used to move the mated vehicles from the VAB to the launch pad. Some areas of the apron and tow-away around the VAB will have to be expanded to handle the loaded crawler as it moves to the crawlerway.

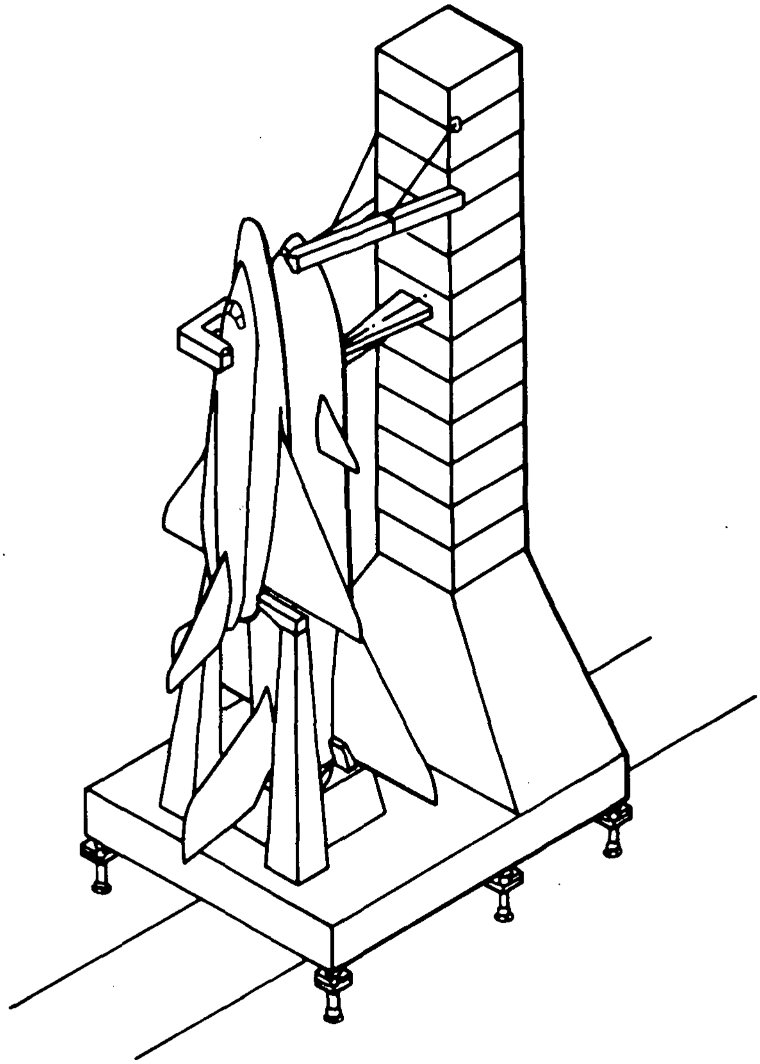


Figure 1.4-8. Modified Mobile Launcher

1.4.6.3 Launch Pad

Use of the mobile launcher concept minimizes the modifications required at pads 39A and 39B. Existing mobile launcher support pedestals, hard stand, flame trench, and flame deflectors can be used.

Some modifications will be required to the interface connections between the pad and the mobile launcher and among the environmental control, gas storage and distribution, and emergency systems at the launch pad. Modifications will be needed to permit emergency egress from the elevator to a safe room.

The propellant and gas storage and distribution facilities at pads 39A and 39B will require minimal changes. Existing LO_2 storage and pumping systems are adequate. At each pad, an 850,000-gallon LH_2 storage sphere and distribution system will have to be added to existing systems to meet launch support requirements.

These systems should have automatic propellant flow and top-off capabilities with a contingency hold and revert capability. The propellant systems must be able to dispose of propellant, especially under emergency detanking situations, and to drain and purge lines after use.

Storage and supply systems for 35,000 gallons of JP fuel must be added at each pad, running through disconnects on the mobile launcher. GN_2 and GH_2 storage and supply systems are required to purge and condition the LH_2 tanks and supply lines. The LH_2 tanks will be purged with GN_2 and then purged with GH_2 before loading of LH_2 begins.

1.4.7 INTERFACES

This section establishes the operational, functional, and technical requirements of the interfaces between the orbiter and space station/payload during the prelaunch, launch, orbiter post-landing, and safing operations. Shuttle vehicle liftoff is defined as that time at which the booster vehicle is released by the holddown arms, and completion of orbiter vehicle rollout is defined as that time at which the vehicle comes to a complete stop after landing and the engines are shut down.

1.4.7.1 Ground Operations - Prelaunch Phase

Transportation

The payload module ground operations will provide the means of transporting the loaded module to the space shuttle for installation in the payload bay while in the horizontal position.

Installation

The space shuttle ground operations will provide the means for installing the module in the orbiter payload bay.

Securing

The shuttle orbiter will provide the means for securing the payload module in the payload bay for all flight and emergency landing conditions.

Installation Verification

The shuttle orbiter will provide the means of verifying that the payload module is secured in the payload bay for safety in flight.

1.4.7.2 Ground Operations - Launch Phase

Fill, Drain, and Vent Connections

The shuttle orbiter will provide access or connections to the payload module resupply tanks for fill, drain, and venting purposes.

Shuttle/Payload

Nominal integrated checkout will be performed with the shuttle on-board checkout system. Any requirement for ground checkout and control of the integrated payload will be provided. The payload checkout will be in the form of a "health" checkout. Payload functional checkout will be with payload supplied systems. Health checkout means a simple go or no-go interrogation prior to launch and/or prior to deployment on orbit.

Integrated Checkout

An integrated checkout of the shuttle-orbiter and payload module will be performed by the orbiter prior to liftoff.

1.4.7.3 Orbital Operations - Information Management

Voice Communications

An S-band two-way duplex voice function will be provided between the orbiter and the space station. The system is capable of simultaneous transmission and reception. The shuttle will provide the capability for communication hardlines to the payload module for intercom and two-way voice transmission.

Communication between passengers in the payload module and the ground will be provided through the shuttle crew's voice channel.

Data Interchange and Tracking

An S-band function for simultaneous transmission and reception of up-and-down data and turnaround of a ranging signal will be provided. The space station transmits and receives pseudorandom noise (PRN) signals; the orbiter receives and transponds.

The shuttle telemetry system will allocate 5 kbs of data for the payload. Formatting will be accomplished with payload systems.

Data Transfer

Provisions for radiating from the payload telemetry system to the ground will be provided in the shuttle antenna system design. Payload telemetry transmitted in this manner will be compatible with shuttle antenna design.

System Status

1. The orbiter will provide the capability of displaying payload parameters on the general display system. All crew safety parameters will be available for continuous monitoring.

2. Access to the shuttle data bus for data management and command will be provided to the payload.

1.4.7.4 Orbital Operations - Payload Deployment and Docking

Deployment

The shuttle orbiter will provide the means for deploying (and repositioning) the payload module from the payload bay.

Access between the shuttle orbiter and the payload module will be provided. Removal of the deployment hardware or any of its parts will not be required.

The environment between the shuttle orbiter crew compartment and the payload module will permit shirt-sleeve operations at all times.

Berthing

Provisions. The station will provide the means (adapter) for berthing to the orbiter's berthing port immediately adjacent to the crew compartment. (This port is approximately 38 inches in diameter.)

Command and Control Responsibility. The orbiter shall be in command and control of the docked configuration and will provide the desired stabilization.

1. Shuttle unmanned. The space station will monitor the caution and warning alarm of the orbiter.

2. Orbiter/space station interface. (a) Electrical power capability will be provided for two power connections. The shuttle EPS will supply up to 47.0 kwh of electrical power in the form of regulated 28 vdc. Power will be limited to 500 watts average, with 800-watt peaks. (b) Capability will be provided at the docking interface for connection to the station communications bus for two-way voice and station data bus for orbiter performance data. (c) Provision will be made for an O_2 and N_2 pressurization of the orbiter by the space station. (d) Air circulation-provisions will be made for air circulation between the orbiter and the space station.

Guidance and Navigation. Orbiter inertial alignment data, deorbit, and trajectory information for earth return will be supplied by the space station.

1.4.7.5 Ground Operations - Post-Landing Phase

Shuttle orbiter ground operations will provide a means to make safe the payload module before its removal from the payload bay after the orbiter has been towed to the safing area.

Shuttle ground operations will provide the means of removing the payload module from the payload bay. After removal from the orbiter, payload module ground operations will provide the means of transporting the module to its maintenance area.

1.5 OPERATIONS

The operations covered in this section are primarily the prelaunch and launch operations conducted at the launch site; however, the predelivery testing that either directly or indirectly influences the launch-site activities or requirements also is discussed.

Because many of the design and overall program objectives have not changed from the 33-foot-diameter space station concept discussed in SD 70-545 (DRL-59), this section is devoted primarily to those items considered unique to the MSS or shuttle launch vehicle. The subjects include test philosophy, the test-related ground operations conducted prior to delivery to the launch site, and the prelaunch and launch operations.

1.5.1 TEST PHILOSOPHY

The overall test philosophy has not changed appreciably from that described in Section 5.0 of SD 70-545 (DRL-59) for the 33-foot-diameter station. The concept is to maximize the standardization of requirements and limits and to integrate qualification testing into the total test program. The basic approach is shown in Figure 1.5-1. The objective remains to develop a cost-effective, integrated launch confidence program that assures that each development, qualification, and acceptance test contributes to the total program with the proper emphasis at the proper time. The guidelines for requiring commonality of procedures, utilization of a central computerized data bank for historical data, integration and optimization of development, and qualification testing have not changed. However, the cost-avoidance considerations for the MSS concept did result in establishing new guidelines to take advantage of the possible utilization of hardware and GSE that will have been developed previously for the shuttle.

1.5.1.1 Development Testing

Proven materials, components, and techniques will be selected whenever possible in view of the limited production quantities and high-reliability requirements. New designs must be verified by analyses, development tests, or a combination of both. The development test effort will be directed primarily to the feasibility/breadboard/prototype compatibility and integration aspects of development testing.

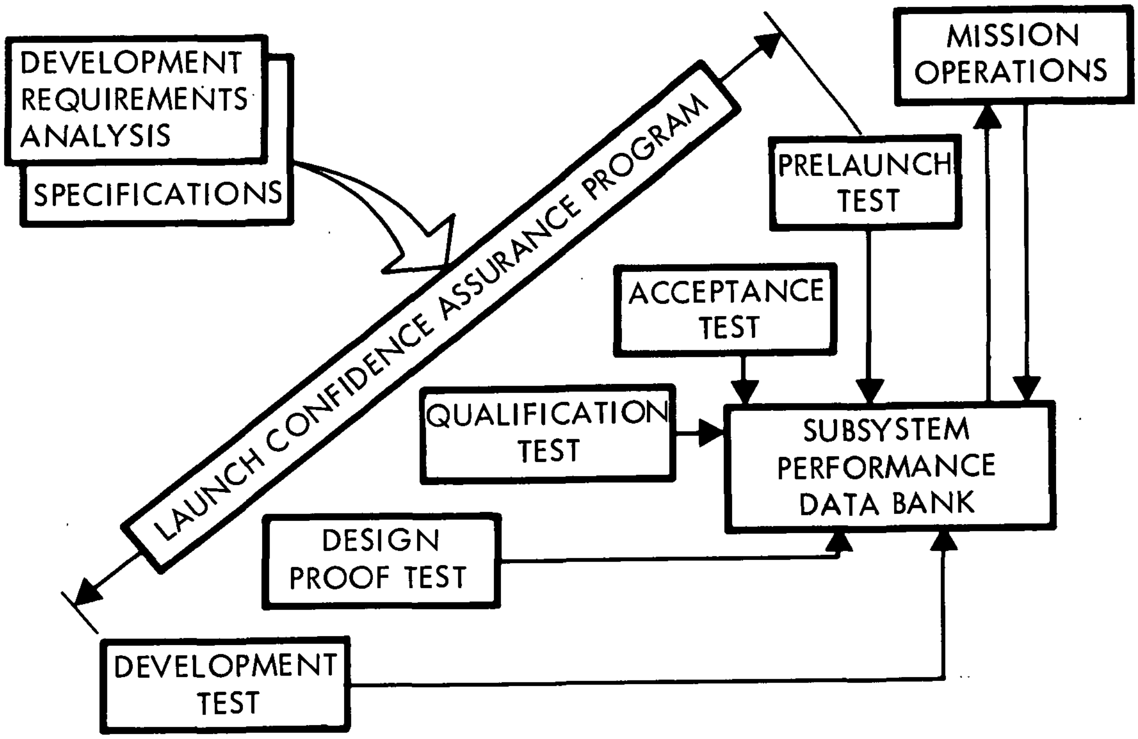


Figure 1.5-1. Integrated Test Program

1.5.1.2 Structural Testing

The structural test vehicle will consist of the complete primary structure of representative space station modules but no secondary structure. The primary structures, structural interfaces, and functional interfaces between modules will be verified statically and dynamically by test, analysis, or a combination of both.

1.5.1.3 Environmental Testing

A fully configured module will not be provided for the acoustics, vibration, and thermal vacuum testing. Test fixtures and simulations in terms of mass and center of gravity will be used where practical.

1.5.1.4 Qualifications Testing

Qualification is a requirement that must be met by each component and thus is not significantly affected by the change in concept from the 33-foot-diameter to the modular space station. Qualification becomes an integral part of the launch confidence assurance, and the test disciplines and rigors are integrated into the total test program.

1.5.1.5 Acceptance Testing

Acceptance testing is designed to verify that an article conforms to contractual specifications with respect to configuration, quality, and performance at the time it is ready for delivery to its next assembly or usage point. This should not change from the 33-foot-diameter concept at the component and subsystem level but will be affected by configuration at the module or complete station level. The concept remains to establish hardware acceptance specifications before initiation of procurement and to standardize test documentation. The tests will utilize the central data bank as a source for comparison data.

Subsystems

Subsystems will be acceptance tested before installation and will be tested to the same operational range expected to be experienced in flight. The tests will include a demonstration of alternate/redundant modes of operation together with the malfunction switching logic by exercise of subroutines inherent to the on-board checkout capability. Electromagnetic compatibility (EMC) will be established at the design level and verified in the normal test and checkout sequence. Special tests at the modular level are not anticipated.

Space Station Modules

At the system level, all alternate and redundant modes of operation must be successfully demonstrated to verify all functional space station interfaces and to assure the on-board checkout capability will adequately status all modes of operation by means of appropriate subroutines. Acceptance of the various modules will be accomplished by a combination of tests utilizing a test tool (MSV--see Section 1.3) and ground computer facility. The on-board checkout capability will be used as a basis of acceptance testing for the space station end items.

Combined tests of those modules required to accomplish the basic station functions (i.e., multiple berthing, power generation, and subsystem control) will be conducted prior to launch of the initial module. These procedures are discussed in more detail in the following section.

1.5.1.6 Integrated and Operational Testing

The Phase B study established a philosophy for testing the 33-foot-diameter station based on the total autonomy of the on-board systems. The study placed the emphasis on checkout at the factory and advocated applying subsystem power continuously from factory checkout through launch. This approach was to have reduced the field site effort to a servicing and launching function. Universal test equipment (UTE) was to have been used for manufacturing checkout through launch. The CCA-3 KSC study analyzed variations of the checkout implementation concepts to include the substitution of the existing acceptance checkout equipment (ACE) and the RCA-110 for the UTE.

The 33-foot-diameter station was to be launched unmanned, but it had power-on and all systems were in an operational condition. Modularization of the space station will require a considerably different concept both for the launch and the prelaunch verification. Because the shuttle concept precludes the launching of a complete station, a philosophy for integrated and operational testing must be devised and optimized to assure compatibility and successful integration of the various modules to be sent into orbit in a cost-effective manner.

Conceptual Considerations

There are many approaches that can be taken in the launching and prelaunch verification operation for the MSS. Many of these concepts have been employed previously for both systems and complete vehicles. Typical concepts would be as follows:

1. A complete modular space station could be assembled at the launch site and an integrated checkout performed prior to the launch of the first module. As the modules were launched, they would be replaced with like modules that could be used as replacements for the modules being returned for refurbishment. The station on the ground would incorporate all changes and modifications to duplicate the configuration of the station in flight. In addition to being used for acceptance testing of experiment payloads, troubleshooting of problems experienced by the station in orbit, updating of spares, checkout of IFRU's, etc.

   This approach would provide a maximum of confidence, insurance, utility, and versatility but also would require a maximum of flight hardware. Although it appears ideal, the full benefits cannot be realized, because the interfaces must be broken before launch.

2. An integrated checkout tool similar to the 33-foot-diameter mission support vehicle could be utilized as a substitute for an actual station. Such a tool could vary in configuration from actual hardware to combinations of electronic devices, computers, and software. The systems could be housed in rooms with docking interfaces or actual modules. It would, however, have the capability to simulate a complete or partial station and would be used to perform integrated checkout of the modules as well as the other functions previously discussed for the backup station concept.

3. A third method could be to perform a checkout of single modules using an interface substitute or piece of GSE to simulate the presence of other modules. The degree of complication of the supporting equipment would dependent upon the overall system design concept. Typical factors of influence would be whether the system was centralized or split amongst many modules, the actual allocation of systems to the various modules, and the functional capabilities assigned to the components or subsystems. For example, a particular design concept for a module may make it feasible to check the module with existing equipment or computers while a different concept may essentially require the space station OBCO equipment, UTE, or equivalent for checkout.

4. A combination of items 1 through 3 could be the most feasible when giving proper consideration to such factors as costs, schedules, hardware availability, state of obsolecence of existing equipment, etc. Also of significant is the 5-year spread in the scheduled launching of the 6-man station and the growth station in view of the requirement for checkout of the experiment and refurbished modules during this period and the post-growth station era.

Test Concept and Operations Support Selected for Launch Site

The concept selected for the integrated and prelaunch operational testing at the launch site is most similar to that described in paragraph 1.5.1.6 under "Cc nceptual Consideration," item 2. Many factors were considered in addition to those directly related to the launch of the space station modules.

The MSS concept extends the launching and supporting operations over a period of several years and, consequently, will change the roles of the manufacturing and launch sites from those generally accepted in the present and past programs. Ordinarily, the production period has usually exceeded or been coincident with the completion of the test operations. In these cases, the manufacturer normally provided engineering and logistics support throughout the entire test and operational program. This mode of operation will not be likely during the shuttle era, because it is probable that many of the contractors and vendors in the project will no longer be involved after the launch of the initial station and the growth station modules have been produced and stored.

It is unlikely the manufacturing facilities and contractor personnel would be retained for the full duration of the program because of the 10-year life requirement for the space station and the 5-year interval between the launching of the initial and the growth stations. Consequently, responsibility for the supporting functions now performed by the manufacturer will have to be assumed by the launch site or some other facility. Typical functions considered to be in this category are as follows:

1. Support engineering and documentation control

2. Spares procurement, maintenance, and storage

3. Software development, maintenance, and control

4. Refurbishment of space station and experiment modules

5. Acceptance testing

    a. Last three initial station modules

    b. Growth station modules

    c. Experiment modules from vendor

    d. Refurbished modules

    e. Recycled modules

    f. IFRU's and GRU's

    g. Software

    h. Modification

6. Maintenance and operation of laboratory-type equipment for component checkout, repair, and calibration

7. Data reduction and test analysis

8. Evaluation of anomalies in support of orbiting station

In DRL-73, it was established that an integration tool will be required at the factory for the development of subsystems and integrated checkout of the initial space station. Utilization of a similar device also would be the most desirable approach to support the majority of the functions previously listed.

An operational implementation and management approach for a concept utilizing an integration tool/MSV at both the factory and shuttle launch site is summarized in Figure 1.5-2. The figures lists the functions proposed to be

1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987

33-FT DIA STA LAUNCH (1977)

INITIAL MSS LAUNCHES (1981)

GROWTH STA LAUNCHES (1987)

INTEGRATION TOOL AT FACTORY

- INTEGRATION TOOL FUNCTIONS
  - SYSTEM DEVELOPMENT
  - INTEGRATED MSS DEVELOPMENT
  - ACCEPTANCE TEST

    SUBSYSTEMS
    STATION MODULES
    EXPERIMENT EQUIPMENT
    MODS
    IFRUS
    SPARES
    REFURBISHED MODULES
    SOFTWARE

  - CREW FAMILIARIZATION
- FACTORY SUPPORT

  ENGINEERING
  SPARES
  REFURBISHMENT

  (FACTORY)

INTEGRATION TOOL (MSV) AT SHUTTLE LAUNCH SITE

- INTEGRATION TOOL FUNCTIONS
  - INDIVIDUAL MODULE CHECKOUT
  - ACCEPTANCE TESTING

    STATION MODULES FROM FACTORY
    EXPERIMENT MODULE FROM VENDOR
    REFURBISHED MODULES
    RECYCLED MODULES - CARGO, EXP
    MODS
    IFRUS & GRUS
    SPARES
    SOFTWARE

  - EVALUATE ANOMALIES IN SUPPORT OF ORBITING STATION
  - INTEGRATED CHECKOUT OF GROWTH STATION
  - CREW FAMILIARIZATION
- SHUTTLE LAUNCH SITE POTENTIAL SUPPORT FUNCTIONS

  SUSTAINING ENGINEERING
  CONFIGURATION CONTROL
  SOFTWARE CONTROL & MAINTENANCE
  MODULE REFURBISHMENT
  SPARES, IFRUS, AND GRUS, PROCUREMENT, STORAGE, MAINTENANCE, & REPAIR

  (LAUNCH SITE & FACTORY SUPPORT)

Figure 1.5-2. MSS Factory/Launch Site Functional Summary performed by the integration tool/MSS at the factory and launch site. It also lists other support-type functions normally provided to the field site by the factory. In addition, the figure lists candidate responsibilities that could logically be transferred to the shuttle launch site/KSC during the MSS era.

An examination of the requirements and schedules indicate the sharing of this equipment between the factory and launch site is feasible. As noted in Section 4.0, this equipment was previously used as a compatibility assessment vehicle and for acceptance testing of the initial station modules but is designated as a mission support vehicle (MSV) while at the launch site. It will be incrementally transferred to the field site in accordance with the schedule shown in Figure 1.5-3 to be available for checkout of the initial station modules as well as providing an operational tool for evaluating any contingencies or changes that may occur during the buildup or in subsequent operations.

Ground Control Concepts

Analyses were conducted during the DRL-59 study to determine the feasibility of using existing equipment such as the RCA-110 or Apollo

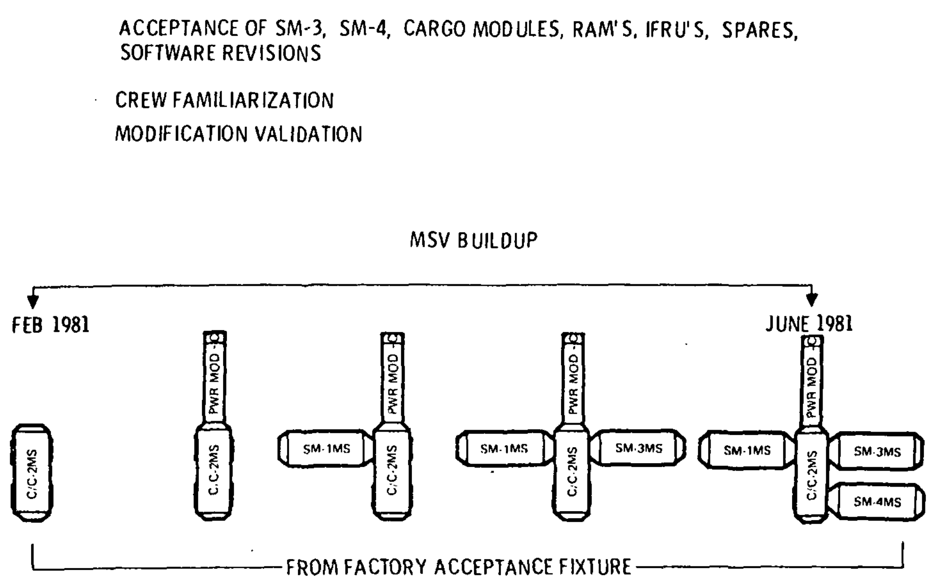


Figure 1.5-3. MSV Element Module Availability Dates at Shuttle Site

acceptance checkout equipment (ACE) as the prelaunch command and control system for the Station A. Similar MSS analyses were not conducted during this study for the following reasons:

1. The test philosophy adopted for the Station A applied power continuously from factory checkout through orbital life. Systems were operative during launch and the servicing operations were conducted on the pad just prior to launch. Prior to final flight closeout, the prime control station. After final closeout, the prime control was transferred to the LCC, because the station was launched unmanned. Universal test equipment (UTE) and the RCA-110A were the candidate control systems considered for the final portion of the countdown, which consisted of cryogenic loading, system checkout, control, and monitoring. Hardwires were used for emergency safing.

   A comparable requirement does not exist for the MSS. The modules are launched in an inactive mode, and many do not contain complete systems. The MSS does not utilize cryogenics, so the major servicing requirement at the pad will be the loading of high-pressure gases. Because the shuttle is considered the primary interface for the MSS modules at the pad, this function and similar operations are to be supported and controlled by the shuttle ground systems. The monitoring of system parameters, if required, will be through the shuttle ISS.

2. It should be noted that the UTE, RCA-110A, or ACE worked in conjunction with the Station A ISS and not independently. Consequently, the equipment was dependent upon the existing software and programming functions performed by the ISS processors. This would not be feasible with the MSS in that all modules do not have data processor assemblies (DPA). Similarly, if the RCA-110A or ACE were to be considered for checkout of the individual modules in place of the MSV, the existing software would not be fully utilized.

3. The degree of obsolescence of existing equipment may make it uneconomical for use during the MSS time period. The comparable items considered useful during the Station A program may be considered obsolete for use during the MSS era because of the delay in launch dates and extended period of utilization. The scope of this study does not provide for this detail level.

4. The MSS test concept minimizes checkout operations after the payload has been mated to the orbiter. These requirements will be supported by GSE and the shuttle ground and ISS systems. The

major module checkout activity occurs prior to transfer to the orbiter station. These operations can be better supported by the ISS provided as part of the MSV.

In view of the previously tested items, the ISS provided with the mission support vehicle and UTE will be the only control and command system considered in this study. UTE will be used to supplement the MSV by providing added control capability for interfacing GSE and facility support. Also, it will be used for the system verification testing of the initial four station modules. The MSV, however, will be available during this period should more comprehensive or integrated type testing be required for contingency situations.

1.5.2 PRELAUNCH AND LAUNCH OPERATIONS

Historically, the trend has been to minimize the prelaunch testing at the launch site for various reasons. The program goal has been to completely prepare the vehicle for launch at the assembly plant and thereby reduce the field site operations to those required to service and launch the vehicle. The concepts of minimal checkout requirements and a high degree of reliability must be attained if an airline-type of operation by the shuttle is to become a reality. Because the design and development of the modular space station is scheduled to lag the shuttle by approximately 4 years, the feasibility of these test concepts and operational procedures will have been demonstrated by the time the MSS is sent to the launch site.

1.5.2.1 Considerations

Factors considered in determining the prelaunch and launch operational requirements for modular space station elements are as follows:

1. Many of the modules will have been in storage prior to being prepared for launch.

2. Compared to the other missions of the Shuttle program, the space station module operations would represent a very small percentage of the total. Therefore, it would be unlikely that the shuttle configuration, interfaces, ground support equipment, and operations would be optimized or standardized to accommodate the space station modules. This could result in deviations to the standard, which may require a more comprehensive checkout prior to mating, utilization of adapters, special GSE, etc.

3. Although many of the modules will be similar, no two will be identical. This results in different checkout and operational

requirements for each module and also increases the probability of late engineering changes requiring rework and system reverification.

4. Safety requirements may necessitate draining the module systems of fluids such as freon prior to shipment, particularly if sent by airplane. This will result in system servicing and validation requirements at the launch site.

5. System validation requirements resulting from engineering changes, faulty components, changeout of life-limited hardware, and software, etc.

As a result of the previously listed considerations, it is planned that the capability for integrated checkout (MSV) be located at the shuttle launch site for the duration of the program.

The extent of the checkout for each individual module will be determined from its system configuration, the time period it has been in storage, data trends, modifications, etc. The requirements and flows for the different modules are shown in Section 2.0.

1.5.2.2 Operational Test Phases

The integrated and operational testing will be divided into two phases. The first phase will cover the time period during which the initial 6-man station is developed and launched, and the second phase will cover the remainder of the operations at the shuttle launch site.

Initial Station Phase

1. Acceptance of the initial station modules is divided into two phases. The first phase is acceptance at the factory of the four modules providing the basic functions of the station, the core, power, control, and environment. These four modules are physically mated and functionally checked out as an integrated unit to provide confidence that they will perform satisfactorily when built back up in orbit. The second phase is the acceptance of the three remaining initial station modules at the launch site. The two phase approach is based upon the following considerations:

   a. Provide acceptance of critical initial modules with maximum exposure to engineering personnel.

   b. Provides home plant training for checkout personnel to be assigned to the launch site.

c. Permits timely phasing of acceptance fixture to mission support role.

2. The modules will be shipped to the field site by air transport in as near a launch ready condition as practical but in an inactive mode. The core module, power module, SM-1, and SM-2 will have been acceptance-tested at the factory, and those modules required to accomplish the basic functions of the space station will have been assembled and checked as an integrated station.

3. The UTE/MSV will be the primary mode of checkout. The initial four flight modules will be subjected only to system verification type tests with the UTE, because these modules previously will have operated as an integrated station at the factory. The remaining three initial station modules will be acceptance-tested with the MSV.

4. Because the shuttle flights dedicated to the launching of the space station modules represent such a small percentage of the total shuttle missions, interfaces and requirements for checkout utilizing shuttle equipment will be minimized. Particularly in view of the short turnaround requirements, airline-type operational concept, and the number of agencies that may be involved. The problems associated with coordinating and effecting changes for a dedicated flight in a timely manner will require careful planning. Measurements to be monitored by the shuttle data system also will be minimized for the same reasons.

5. The checkout and servicing primarily will be accomplished in three areas. A receiving and checkout facility similar to the MSOB or low bay, a shuttle checkout/integration facility, and a launch pad. These areas and a typical flow are illustrated in Figure 1.5-4. Representative functions are as follows:

   a. Receive and offload module

   b. Receiving inspection and configuration verification

   c. Subsystem verification tests of modules accepted at the factory and acceptance testing of the other modules.

   d. Install in orbiter

   e. Servicing and shuttle/payload interface checks

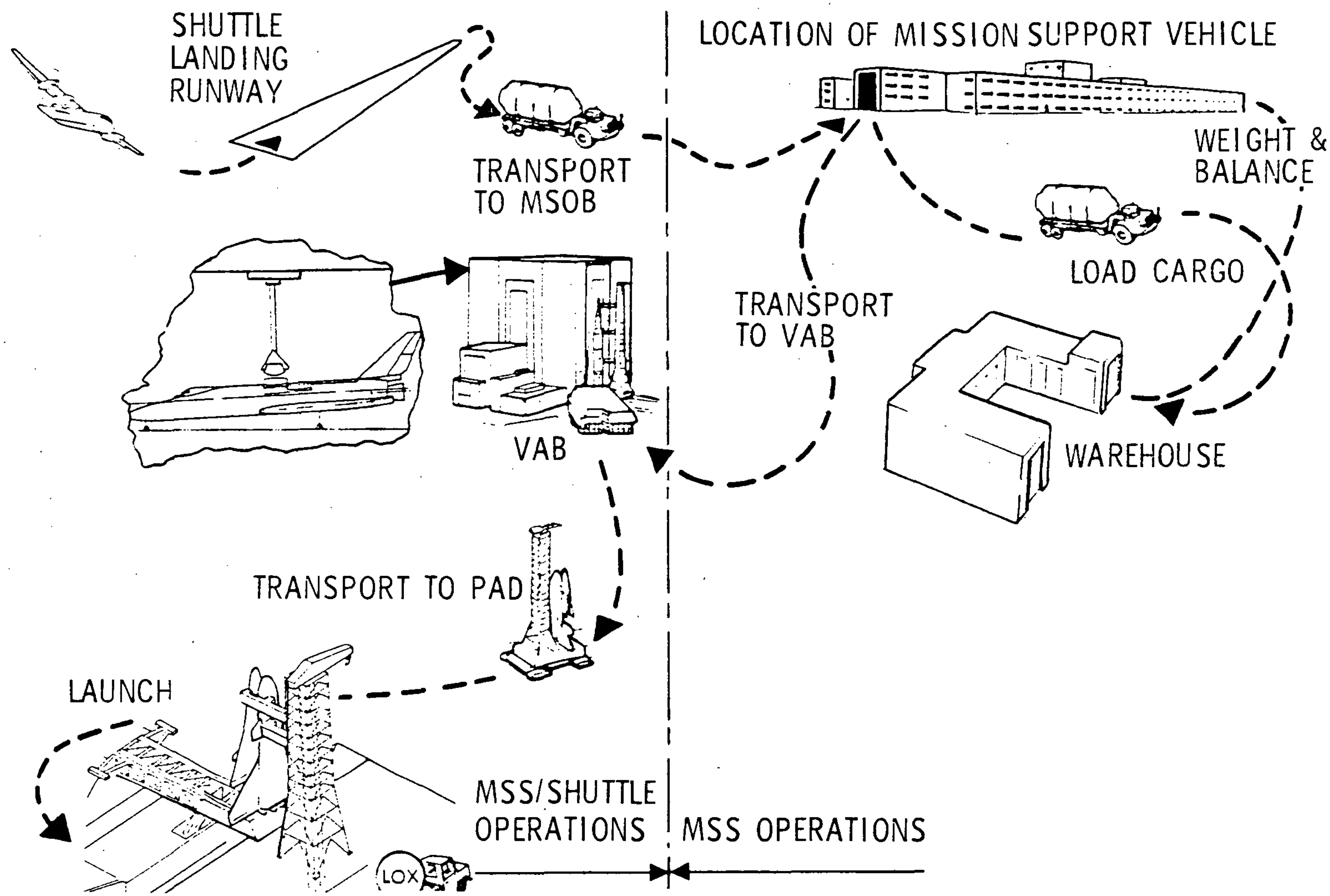


Figure 1.5-4. Typical MSS Module Flow at Launch Site

f. Move to pad

g. Service and launch

Post-Initial Station Phase

1. Subsequent to the transfer of the integration fixture to the launch site, many of the associated functions will be transferred to the shuttle site, because the factory will be phasing out the production of the station modules. In this study it is assumed the field site would then assume responsibility for programming and software.

2. Acceptance test of the growth space station modules will be accomplished at the launch site. Similarly, experiments requiring integrated-type testing will be sent directly to the launch site.

3. Planned maintenance and refurbishment of cargo and experiment modules returned from orbit will be done at the launch site.

4. Prelaunch and launch operations essentially will be the same as described in the previous phase.

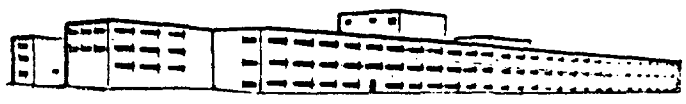
1.5.2.3 Operations and Facilities Summary

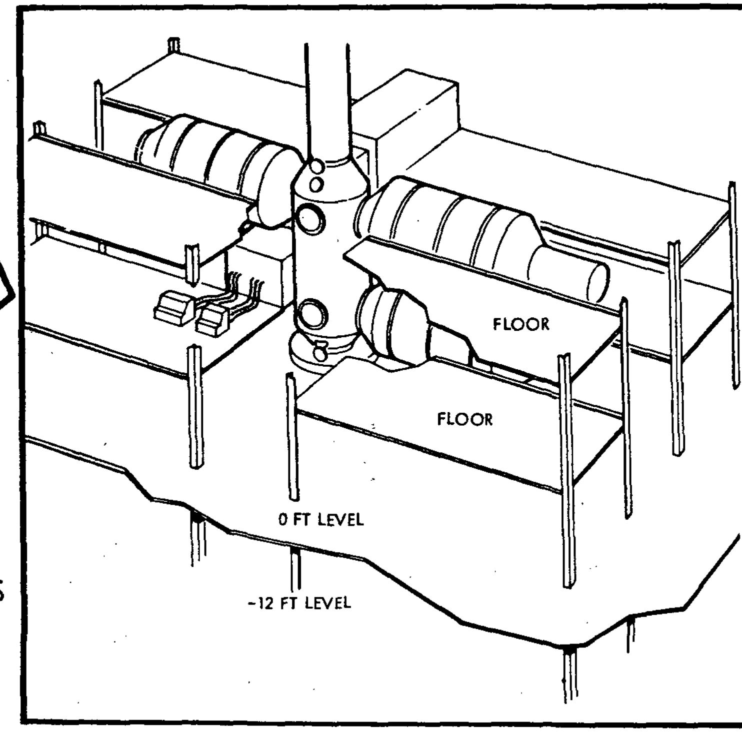
The prelaunch and launch operations for the MSS have been identified and flow plans prepared for the various modules. An assessment of the KSC capability to support the requirements was conducted, and the major facilities and equipment were identified. The operations, facility requirements/ modifications, and control and monitor systems for the MSOB, VAB, and pad are summarized in Figures 1.5-5, 1.5-6, and 1.5-7.

1.5.3 IMPLEMENTATION SCHEDULE

The key events occurring at the launch site during the prelaunch and launch operations are shown in the master program schedule (Figure 1.5-8). The schedule indicates the general activity milestones, completion of facility and GSE activation and checkout, and the initial station launch schedule. The utilization of the MSV for the initial station launches is concerned mostly with system verification tests with flight modules operating with the core module 2-MS and SM1-MS elements of the MSV.

The indicated milestones are those required to support the MSS program and do not necessarily reflect the requirements imposed by other elements of the Shuttle program.



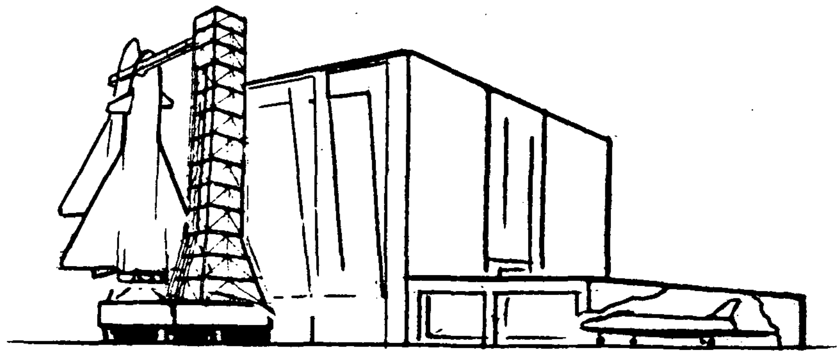


OPERATIONS
- RECEIVING INSPECTION
- MODULE SYSTEM VERIFICATION TESTS
- BERTHING/DOCKING & MODULE I/F FIT CHECKS
- ACCEPTANCE TESTING — MSS & EXPERIMENTS
- MODULE REFURBISHMENT OPERATIONS

REQUIREMENTS
- GH_2 AND DISTRIBUTION SYSTEM — FUEL CELL & SABATIER
- GO_2 AND GN_2
- VENT STACK SYSTEM FOR GH_2 & CH_4 — SABATIER
- MSV INSTALLATION FACILITY MODS AND UTILITIES
- CRANE SYSTEM — HANDLING & WEIGHT AND BALANCE
- R/F SUPPORT EQUIPMENT
- CLEAN ROOM ENVIRONMENT

CONTROL AND MONITOR SYSTEM
- MISSION SUPPORT VEHICLE ISS
- GSE AND UTE

Figure 1.5-5. MSOB Operations and Requirements

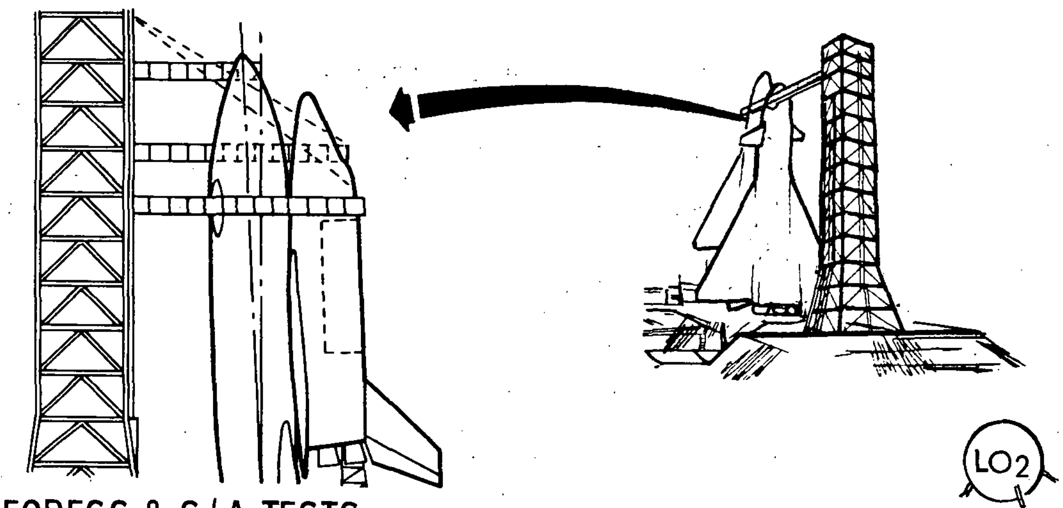


OPERATIONS
- ORBITER LOAD AND UNLOAD
- VERIFY INTERFACES
- SUPPORT SHUTTLE INTEGRATED TESTS
- MONITOR MODULE SYSTEMS ON SHUTTLE ISS

REQUIREMENTS
- OVERHEAD CRANES
- ACCESS PROVISIONS
- COMMUNICATIONS
- GROUND POWER AND CONDITIONED AIR

CONTROL AND MONITOR SYSTEMS
- SHUTTLE ISS
- GSE

Figure 1.5-6. VAB Operations and Requirements



OPERATIONS

- EMERGENCY EGRESS & S/A TESTS
- HIGH PRESSURE GAS LOADING
- LOAD PASSENGERS & TIME-CRITICAL CARGO LAUNCH

REQUIREMENTS

- PROVISIONS FOR LOADING GASEOUS N_2, O_2 & H_2 - MANUAL DISCONNECT
- EMERGENCY EGRESS - DUAL
- ACCESS - PASSENGER & SERVICING UMBILICALS
- GASEOUS H_2 EMERGENCY VENT - POWER MODULE

CONTROL AND MONITOR SYSTEMS

- SHUTTLE ISS
- SHUTTLE GROUND SYSTEM

Figure 1.5-7. Pad Operations and Requirements

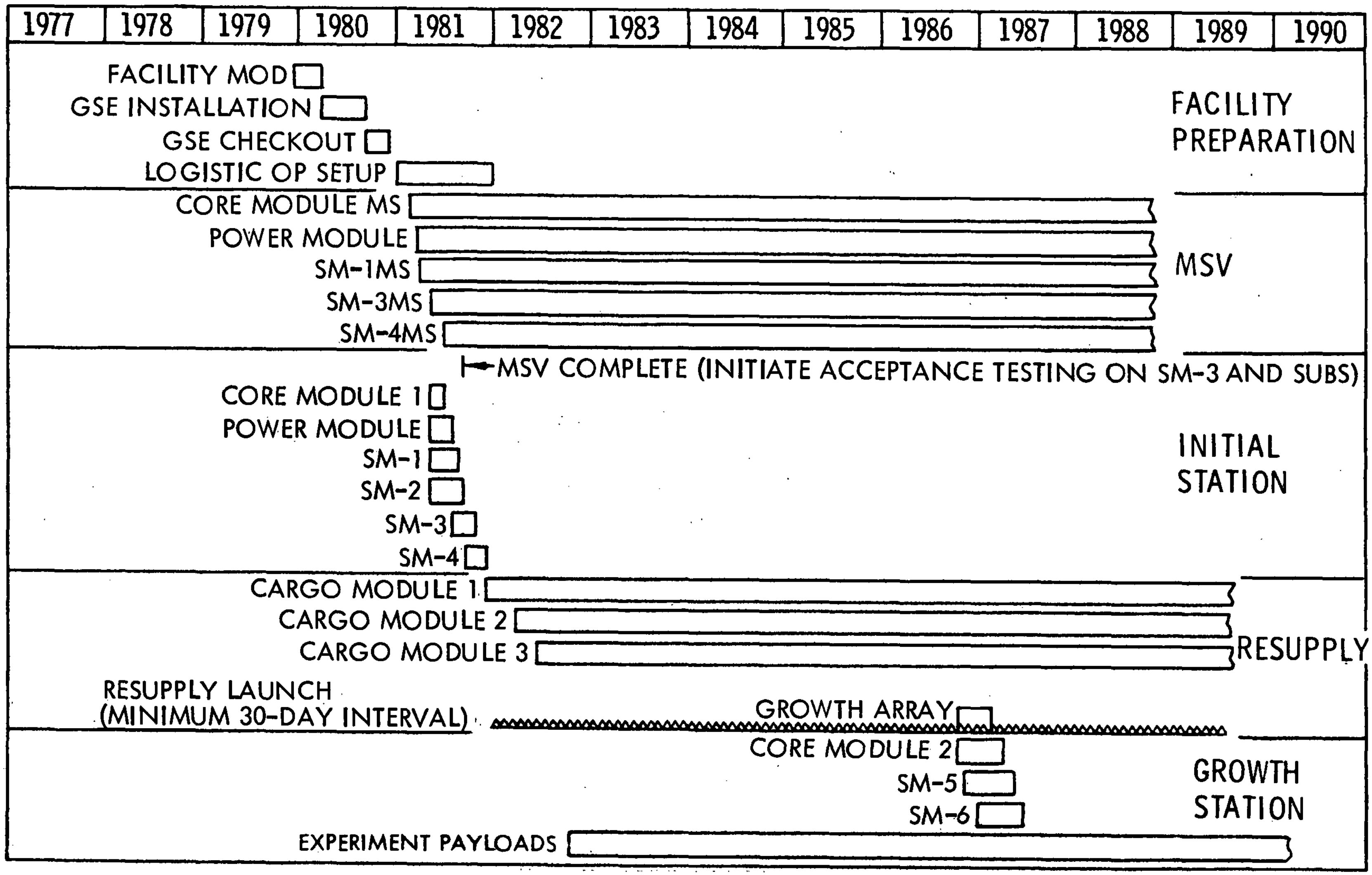


Figure 1.5-8. Launch Site Space Station Program Schedule

2.0 FLIGHT ARTICLE OPERATIONS ANALYSIS

2.1 MODULAR SPACE STATION SUBSYSTEM DEFINITION

The subsystems comprising the MSS are defined in the following separate categories:

- Environmental control and life support (ECLSS)
- Electrical power (EPS)
- Guidance and control (G&C)
- Reaction control (RCS)
- Information (ISS)
- Structural and mechanical
- Crew habitability

It is necessary to present an integrated systems description of the subsystems to provide a more cohesive of understanding of the MSS, because a particular subsystem may span several or all of the MSS modules. For example, all of the modules contain components of the ECLSS, but none contain this subsystem in its functional entirety. In some cases, the subsystem descriptions are the same as those for the Station A concept, because the hardware design has not changed appreciably.

The MSS subsystem analyses were initiated using an extensive legacy of subsystem trades and analyses data from previous space station studies. Trade options eliminated in previous studies for reasons not related to configuration were deleted for the MSS.

ECLSS selection was based on results of trade studies involving sizing, station buildup, station configuration, and penetration into potential problem areas. The sensitivity of the ECLSS concept to MSS configurations was evaluated, and it was determined that, in general, the effect of the configuration was not significant. It was expected heat rejection and the number of ECLSS hardwire units would vary considerably with configuration, but this did not occur.

ECLSS modularity studies indicated the majority of the ECLSS should be centralized rather than installed separately in each module to minimize complexity. Separate atmosphere temperature control in each module was recommended to avoid large docking interface ducts and to increase flexibility.

Humidity control on a central basis was selected to minimize the number of units and to reduce the coolant loop and water management interface complexity.

A core module pool concept of ducting was selected for the circulation of air. Air is bled from all modules and processed through centralized revitalization systems for the removal and control of CO_2, humidity, and environments. A water/freon system was selected for thermal control.

All requirements for cryogens were deleted in the MSS design. However, there may be small amounts required for some of the experiments. The gases utilized for the MSS are oxygen, hydrogen, and nitrogen. The nitrogen is used only as a diluent of the MSS atmosphere, while the oxygen and hydrogen are used in many of the systems including the fuel cells and reaction control subsystem.

Nitrogen is delivered to the station as a high-pressure gas by the cargo module. The primary source for the oxygen and hydrogen is through the electrolysis of water. Water is supplied to the station by the cargo module, and energy from the solar arrays is used for the conversion process. Low-pressure (300-psi) accumulators are located throughout the station for storage and as an integral part of the various subsystems in addition to the high-pressure N_2 and O_2 tanks located in the power module.

Reclamation of oxygen from CO_2 was selected as a preferred concept. The H_2 depolarized cell was selected for the removal of CO_2 from the station atmosphere. The H_2 depolarized cell operates somewhat similar to a fuel cell and accepts CO_2, O_2, and H_2 as input and evolves CO_2 and H_2O vapor at separate locations. The Sabatier system was selected for CO_2 reduction.

Showers and sinks are provided for body hygiene. Flushing-type urinals and dry john's are utilized for disposal of body wastes. A dryer/compactor is used for the processing of trash. Trash is stored and returned to earth, and all waste water is reclaimed.

Water is reclaimed by a vacuum distillation and compression (vapor compression) subsystem. It employs chemical urine pretreatment, a rotary drum vacuum distillation unit with an integral vapor compressor, and a post-treatment section of bacteria filters and a charcoal filter. Water also is produced by the fuel cells.

The special life support equipment consist of fire detection and control and systems for supporting extravehicular and intervehicular activities (EVA/IVA). Multiple fire detectors and portable CO_2 extinguishers are located throughout the station for fire protection. Goggles, oxygen tanks, and masks are provided for crew protection. The EVA/IVA support systems consist of pressure garment assemblies (PGA) and portable life support systems (PLSS) similar to those used on the Apollo program. A water heat exchanter utilized in the thermal control system and lithium hydroxide LiOH is used for CO_2 removal.

The functional scope of the EPS is to store, generate, regulate, control, and condition electrical power, including backup and emergency power, required by the space station for the full duration of the mission. Primary power generation is achieved by solar arrays. Secondary power generation is included to satisfy premanning and emergency requirements and safety criteria. Fuel cells were selected for power generation and are used in conjunction with electrolysis units to effect a power storage system. Excess power from the solar arrays is used to convert water into gaseous oxygen and hydrogen, which is utilized by the fuel cells to produce electrical power by reconverting the H_2 and O_2 back into water. The fuel cells supplement the primary solar arrays during the eclipse periods, emergencies, peak and excess loads conditions, etc.

The fuel cells are supplemental during the first 60-day buildup period by batteries, which are used for emergency power. Fuel cell 1 is activated prior to separation of the core module from the shuttle and is used as the primary power source until solar power is available. Fuel cell 2 is used as a backup for fuel cell 1. A small battery is provided to supply power during the interim period required to bring fuel cell 2 on line in case fuel cell 1 should fail. In case both cells fail, a larger battery is provided which would supply power for the 96 hours that is required to get a shuttle on station to perform the necessary corrective action.

The guidance and control subsystem is essentially the same as for that used in the Station A concept.

The reaction control subsystem (RCS) provides the forces necessary for control of the MSS. A secondary function of the RCS is to provide storage for fluids common to it and other subsystems. Whenever possible, common fluids are used by the RCS, environmental control and life support subsystems (ECLSS), and electrical power subsystem (EPS). In this manner, the number of resupplied fluids and types of tankage can be reduced. H_2 and O_2 were selected as the propellant and oxidizer for the RCS engines, so the subsystem has primary interfaces with the EPS and ECLSS.

The information subsystem includes the data processor assembly (DPA), the display and control assembly, the software (computer-program) assembly, and the communications assembly. This subsystem provides support to all other subsystems for automation, performance monitoring, and configuration control and provides the facilities to permit the crew to monitor, manage, and control vehicle and mission operations. It also provides housekeeping support to integral or attached experiment modules (or decks) and can be extended into the RAM areas to support experiment operations and data handling.

The MSS information subsystem has the same major functional requirements as identified for Station A. The differences in configuration of the two stations, however, affect the way in which the hardware is assembled.

Food is provided in many forms: dried, frozen, thermostabilized, and fresh. A freezer and refrigerator are provided for the storage of perishables. A microwave oven, resistance oven, and reconstitution unit are provided for food preparation. The backup galley consists of a reconstitution unit, Skylab heating trays, dried, and thermostabilized food.

2.1.1 ENVIRONMENTAL CONTROL AND LIFE SUPPORT SUBSYSTEM (ECLSS)

The ECLSS and its assemblies are shown in Figure 2.1-1. The numbers by each subsystem box in the figure refer to the paragraph numbers of the subsystem descriptions provided in this section. The functional block diagram in Figure 2.1-2 indicates the interfaces of the various subsystems and their functional role in the ECLSS as a whole.

2.1.1.1 Gaseous Storage

The gaseous storage system for the normal operation of the MSS consists of one O_2 and three N_2 tanks, each 33 inches in diameter, which are located in the power module. These gases supply the breathing atmosphere for the station in the same mix-ratio and pressure as is experienced in the earth environment. The main purpose of the N_2 is to act as a diluent to the O_2, leakage makeup, and station repressurization. In addition, the O2 supplies breathing gas for the PLSS and PGA, as well as functioning as an oxidizer for the RCS in an emergency.

For emergency conditions, the cargo module will contain one 30-inch-diameter O_2 tank for EVA support and three 29-inch-diameter tanks for RCS usage. In addition, the cargo module will contain six 33-inch-diameter tanks of N_2 for station leakage and three 30-inch-diameter H_2 tanks for RCS operation. The storage requirements discussed to this point apply to the initial station. The additional emergency requirements

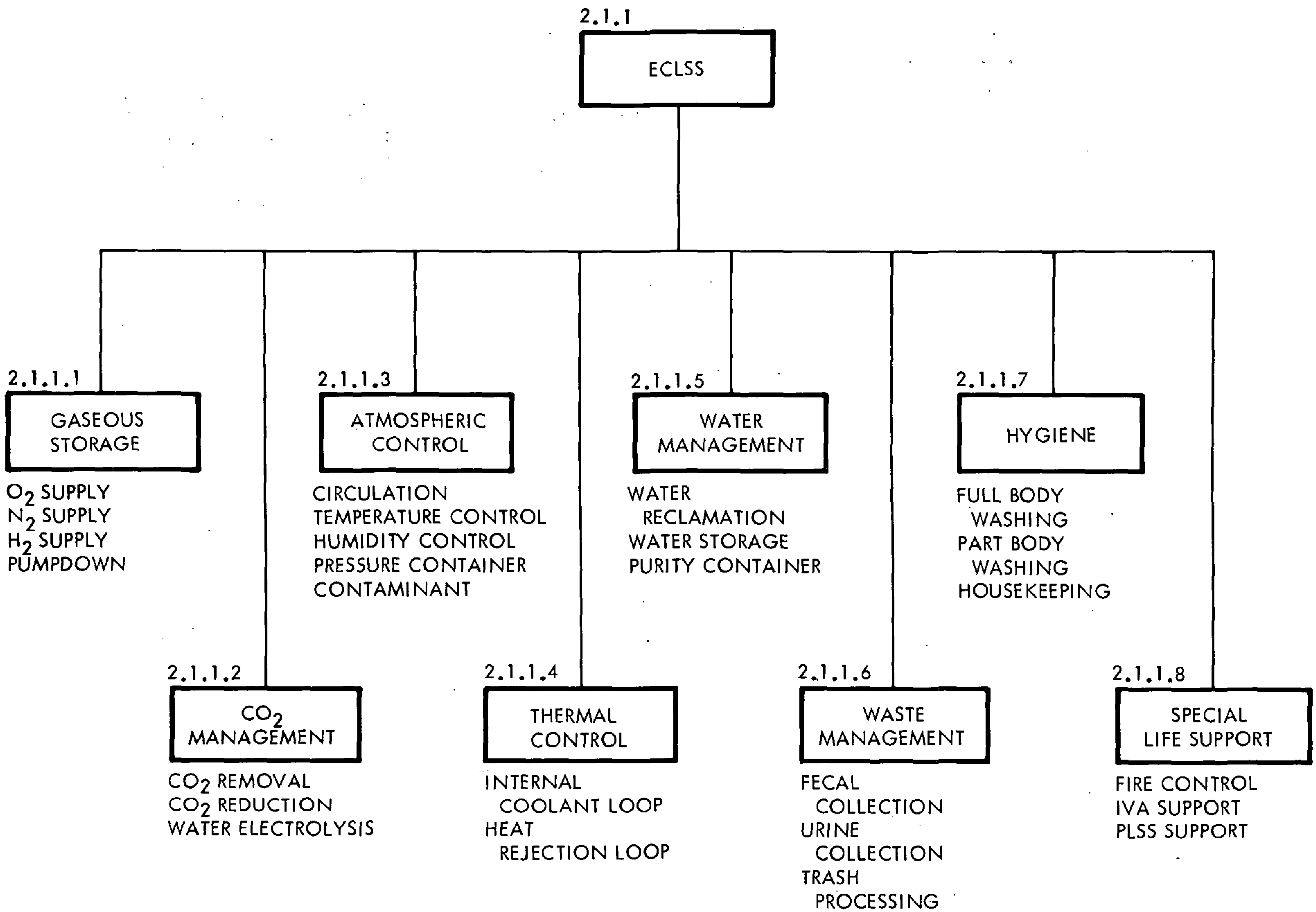


Figure 2.1-1. ECLSS and Assemblies

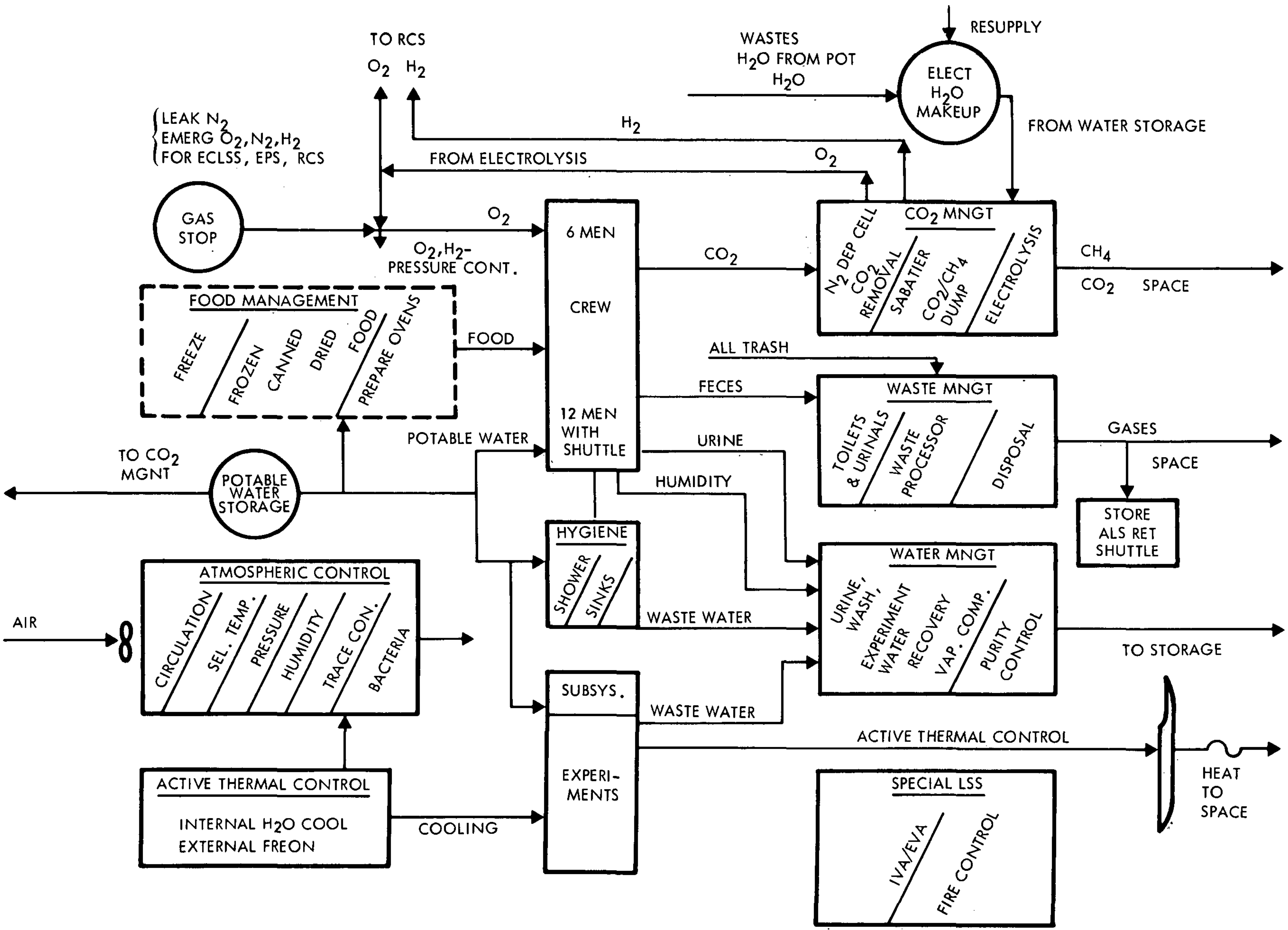


Figure 2.1-2. ECLSS Interfaces and Subsystems Functions

for the growth station consists of four 33-inch-diameter tanks of N_2, one 29-inch-diameter O_2 tank, and three 30-inch-diameter H_2 tanks.

The total gaseous storage requirements are shown in Figure 2.1-3; and all tanks contain gas pressures of 3000 psi.

The pumpdown unit for the IVA airlock with TBD characteristics is part of the gaseous storage system.

The buildup mode or premanning phase of the initial station will require a total of seven O_2 tanks, four in the core module and three in the power module; all of the tanks are 26 inches in diameter. A like number of H_2 tanks are required with the same location distribution and are 33 inches in diameter. The buildup gas requirements stated previously are necessary to operate the four fuel cells in the core module during the premanning phase (first 60 days).

2.1.1.2 CO_2 Management

Humidity controlled air from the MSS atmosphere, containing CO_2 caused by crew occupancy, will be routed through a CO_2 removal unit (H_2 depolarizer). The CO_2 is removed from the air as a constituent and sent to a CO_2 reduction apparatus (Sabatier unit); the air with CO_2 removed is returned to the MSS air return. In the Sabatier unit, the CO_2 is reacted with H_2 forming methane (CH_4) and water. Some of the CO_2 is not reduced and is pumped with the CH_4 to an accumulator for venting to free space. The water byproduct of the reduction process is pumped with water from the storage system to an electrolysis unit. The water is disassociated into its constituents, H_2 and O_2, and approximately 24 percent of each gas is recycled to the H_2 depolarizer and reduction unit for continued reduction of CO_2. The remaining 76 percent of each gas is sent to the RCS accumulator for subsequent utilization to produce thrust for MSS orbital control. A schematic of the repressurization process previously described is shown in Figure 2.1-4.

2.1.1.3 Atmospheric Control

The atmospheric control subsystem provides for control of ventilation, temperature, humidity, pressure, partial pressure of O_2, trace contaminants, and bacteria.

A core module pool concept was chosen for the duct system, which greatly simplified the core module ducting and obviated the necessity for dedicated ports and special control valves in the process module (SM-2 and SM-3).

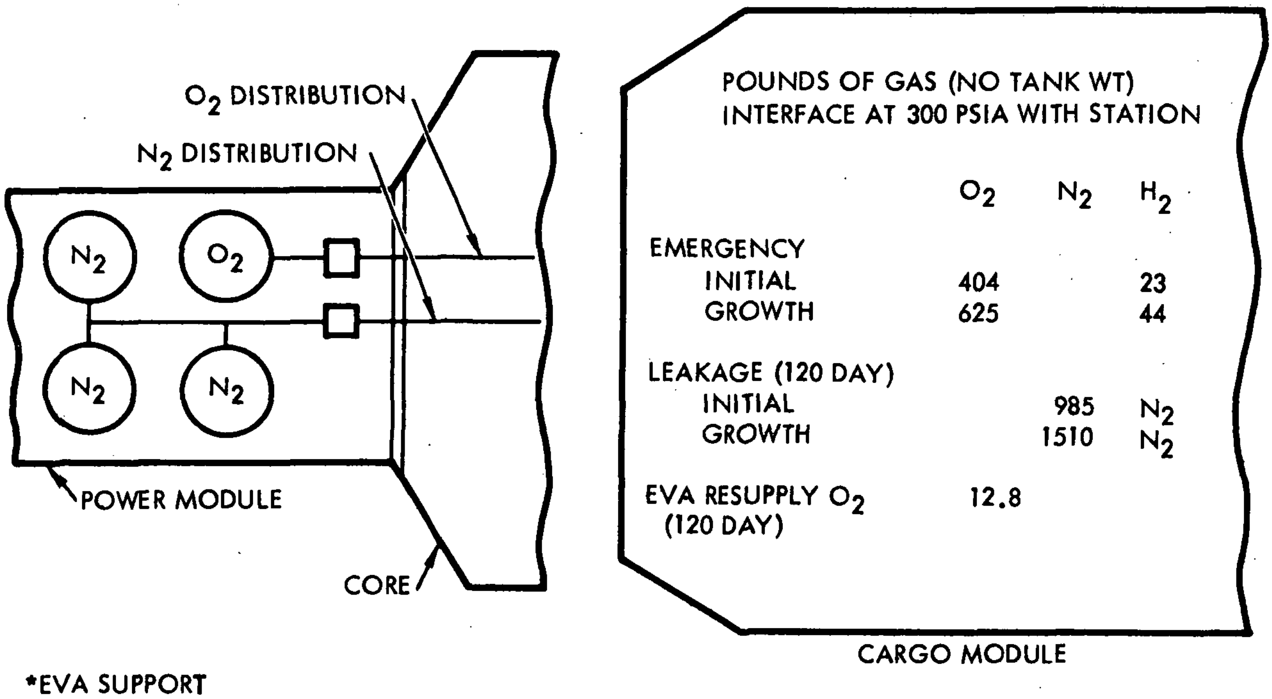


Figure 2.1-3. Gaseous Storage

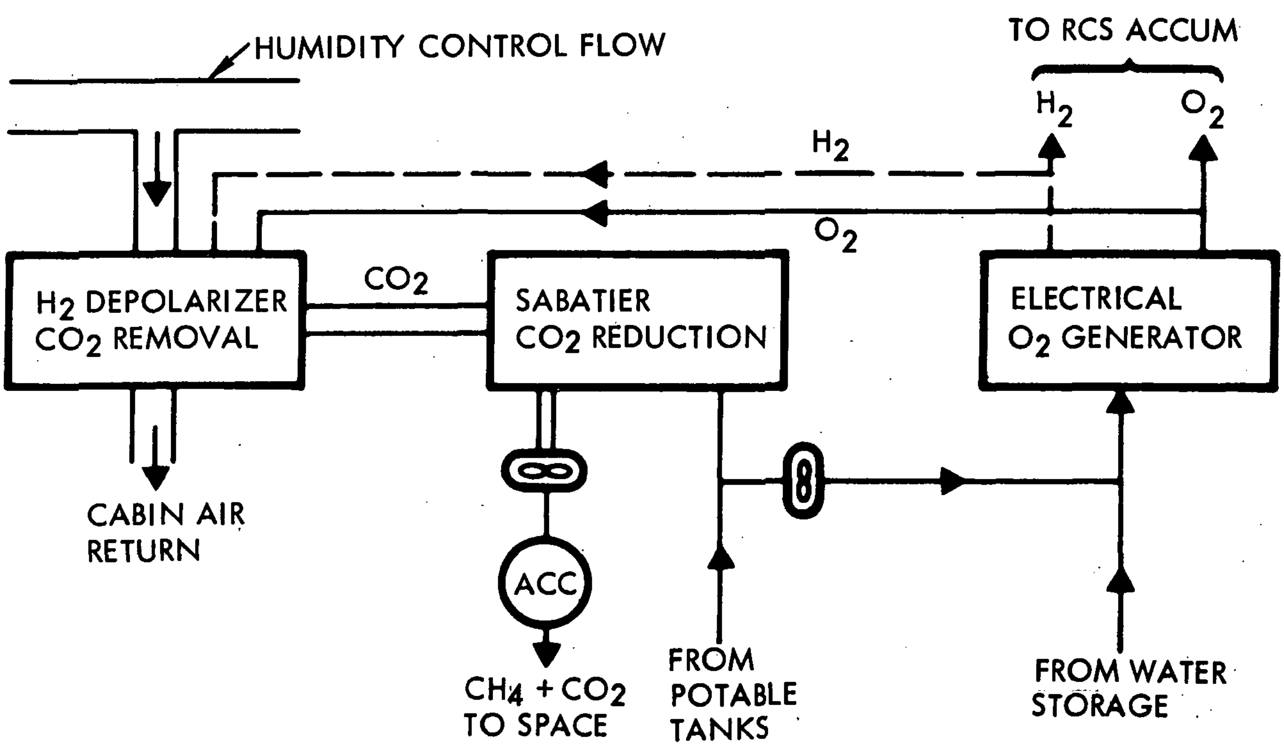


Figure 2.1-4. CO_2 Management

Figure 2.1-5 is a schematic representing the air revitalization loop performance. The core module pooling duct circulation is 1500 cfm with 50 to 100 cfm minimum bleed to each module via control valve sensing humidity. A circulation of 400 cfm is required for modules with a 6-man maximum loading. Also, as shown in the figure, 400-cfm flow is required to the condensing heat exchanger, 60-cfm flow to the H_2 depolarizer (CO_2 removal unit), and 180-cfm flow to the contaminate control. The process unit inlet at maximum loading of the MSS is 2.78 mm Hg PPC02 and 9.9 mm Hg PPH20 at 52.9 F dew point.

2.1.1.4 Thermal Control

The initial MSS, 6-man configuration has a heat load requirement of 103,300 Btu/hour (30.3-kilowatt equivalent); the growth station, 12-man capability, has a 133,000 Btu/hour (39.0-kilowatt equivalent) requirement. This heat load is managed by the thermal control system utilizing an internal loop using water as the heat transfer medium and an external loop that uses freon (F-21). The exchange of the heat load is accomplished in the freon/water intercooler (heat exchanger) located in SM-1.

Figure 2.1-6 and 2.1-7 schematically depict the thermal control internal and external coolant loops, respectively. Radiators are located on the modules which radiate station heat loads to free space.

Figure 2.1-6 schematically depicts the thermal control internal and external coolant loops, respectively. The radiators are located on the modules which radiate station heat loads to free space.

Figure 2.1-6 shows that the heat load of the individual modules is monitored and controlled as a function of the limitations of the most critical equipment or outlet temperature. The water pump shown in the figure has a flowrate operating capacity of about 2300 pounds per hour of water and inputs approximately 2600 Btu/hour with a consequent increase in water temperature of about 1 F.

The freon (external) loop shown in Figure 2.1-7 includes the radiator system of the individual modules. The flowrate (W) of the freon is about 16,000 pounds per hour to transfer the module internal heat loads from the F-21/H20 intercooler. The freon loop control for a typical module is shown in Figure 2.1-8. The outlet temperature from the radiators (8 shown in the figure) is controlled by a flow proportioning control that directs the freon to the set of radiators either away from or toward the sun-side of the module, depending upon the outlet temperature required from the radiators.

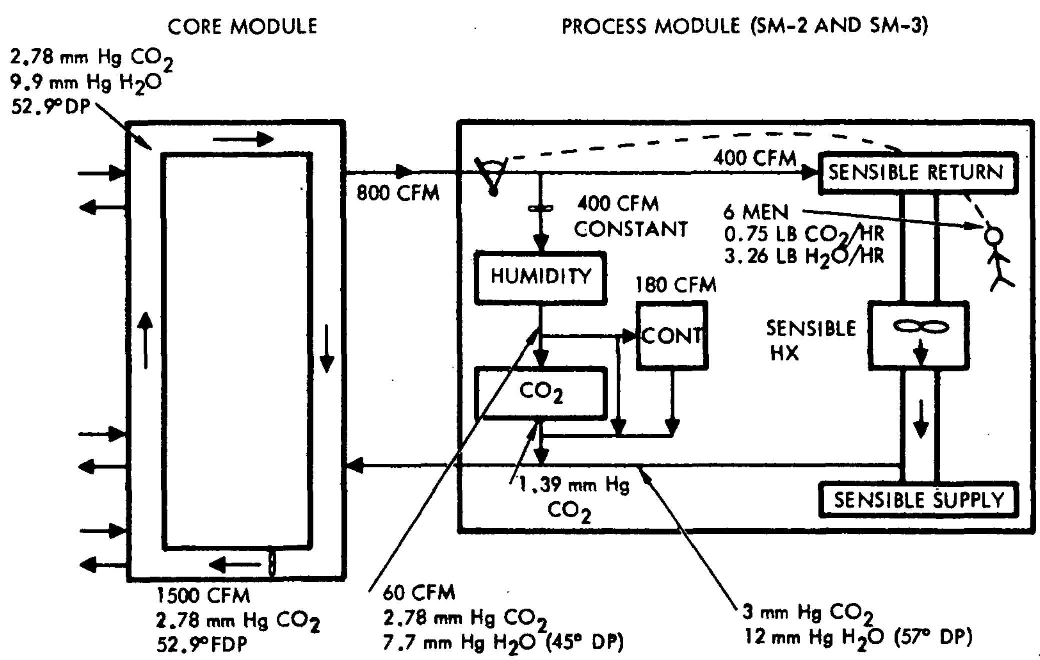


Figure 2.1-5. Air Revitalization Loop Performance

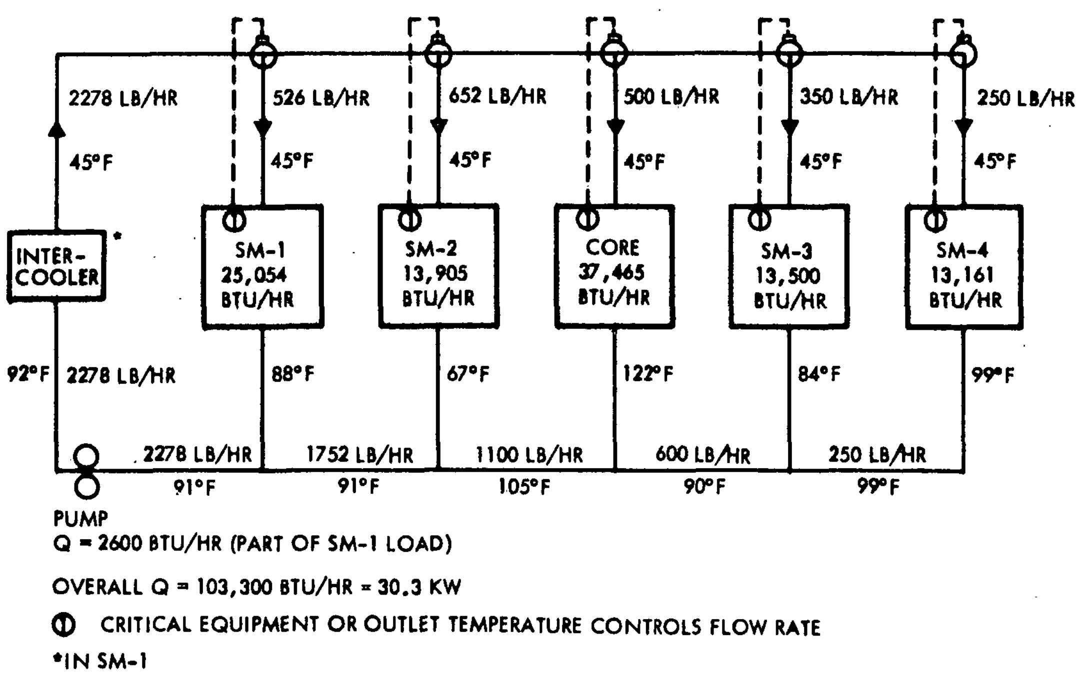


Figure 2.1-6. Initial Station H_2O (Internal Loop)

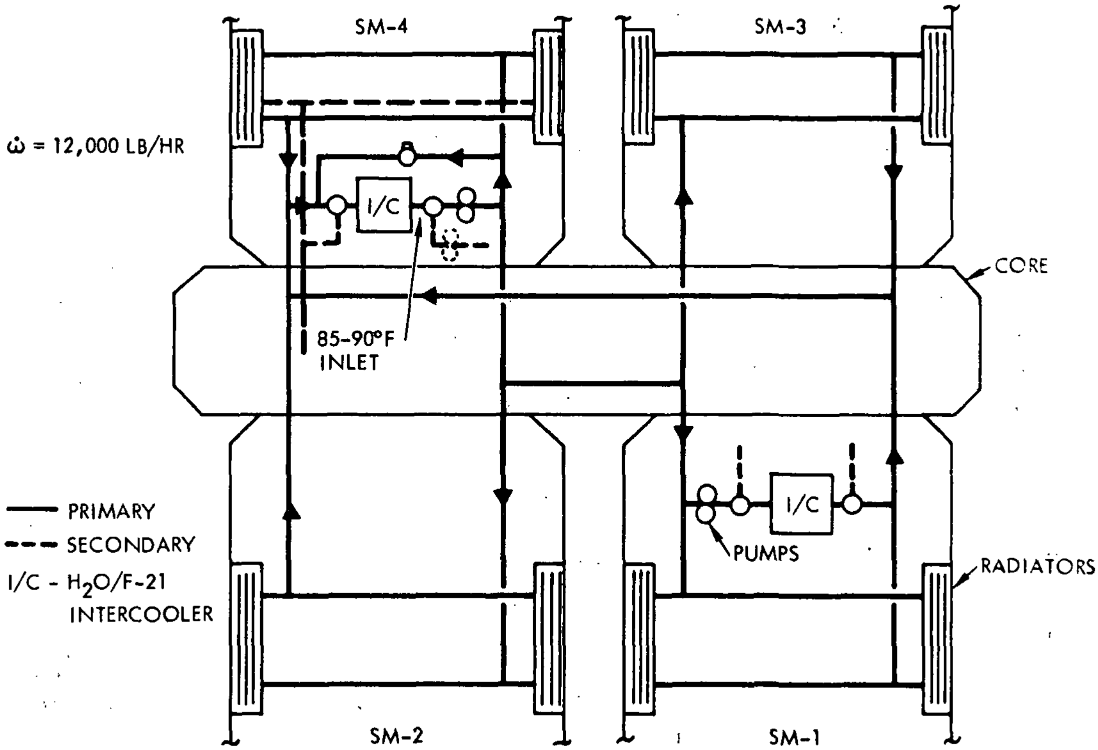


Figure 2.1-7. Freon Loop Block Diagram

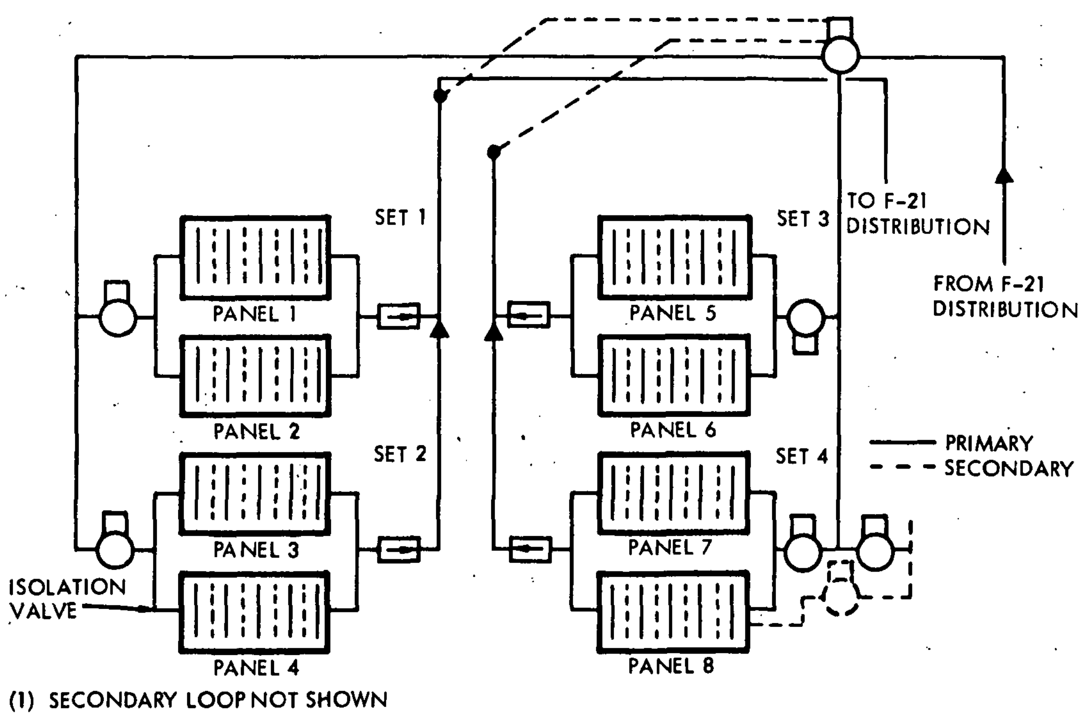


Figure 2.1-8. Module Radiator Arrangement

2.1.1.5 Water Management

The water management system provides for water electrolysis, water resupply, waste-water recovery, experiment support, emergency reserve and storage of the vapor/compression (V/C) vent gas.

Figure 2.1-9 shows the water management assembly distribution throughout the initial MSS. Figure 2.1-10 is an integrated water storage schematic that shows the interfaces of the water management system with other water-producing/using elements of the EPS, such as fuel cells and electrolysis units. Figures 2.1-9 and 2.1-10 show the cargo module water supply for the electrolysis units.

The water reclamation system is one of the more complex assemblies of the water management system, which operates on a vacuum distillation/compression (vapor/compression) principle.

Vapor compression refers to a vacuum distillation process with some type of artificial gravity and intermediate vapor compression. This sub-assembly presented in Figure 2.1-11 employs chemical urine pretreatment, a rotary drum vacuum distillation unit with an integral but externally mounted vapor compressor, and a post-treatment section of bacteria filters and a charcoal filter.

Waste water is received and stored in the pretreatment tasks where a pretreatment chemical from the storage tanks is added to chemically fix the free ammonia and kill the bacteria. Two tanks are used; one receives waste water while the other discharged collected water to the still. As the waste passes through the evaporator, the water vaporizes at near ambient temperature and a reduced pressure. In the compressor, the vapor pressure and temperature are raised above the levels in the evaporator so that a temperature difference exists between the condenser and the evaporator. Thus, when condensation takes place, the heat of condensation is transferred by conduction to the evaporator and therefore conserved. Any liquid that is not evaporated in the evaporator is transferred to a solids dryer associated with the still. The solids remains in the dryer and the evaporator vapor returned to the evaporator section of the still.

The reclaimed water in the condenser is continuously removed and pumped through a series of charcoal and bacteria filters. If the conductivity sensor indicates unsatisfactory water, the processed flow is automatically diverted back to the urinal.

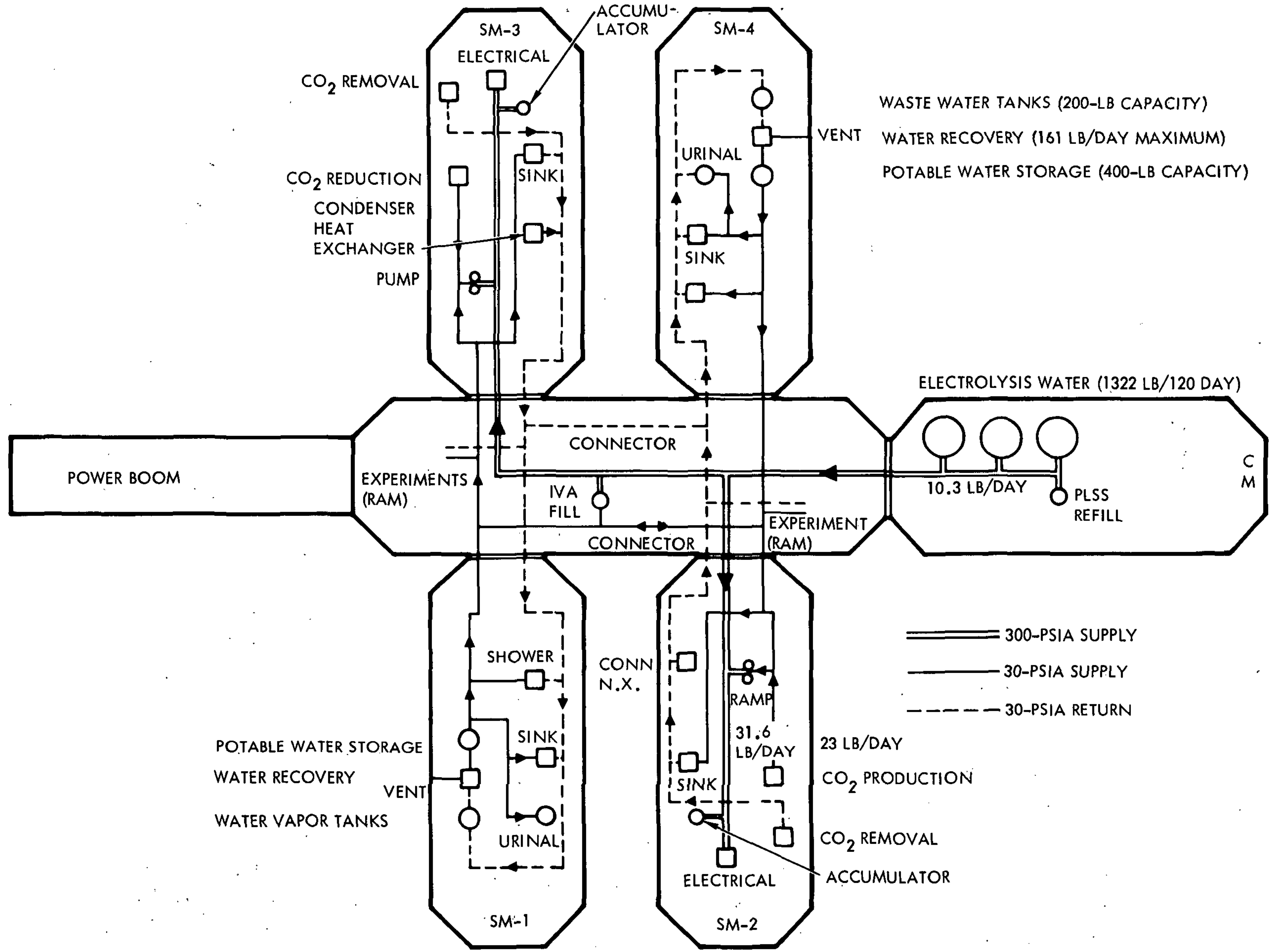
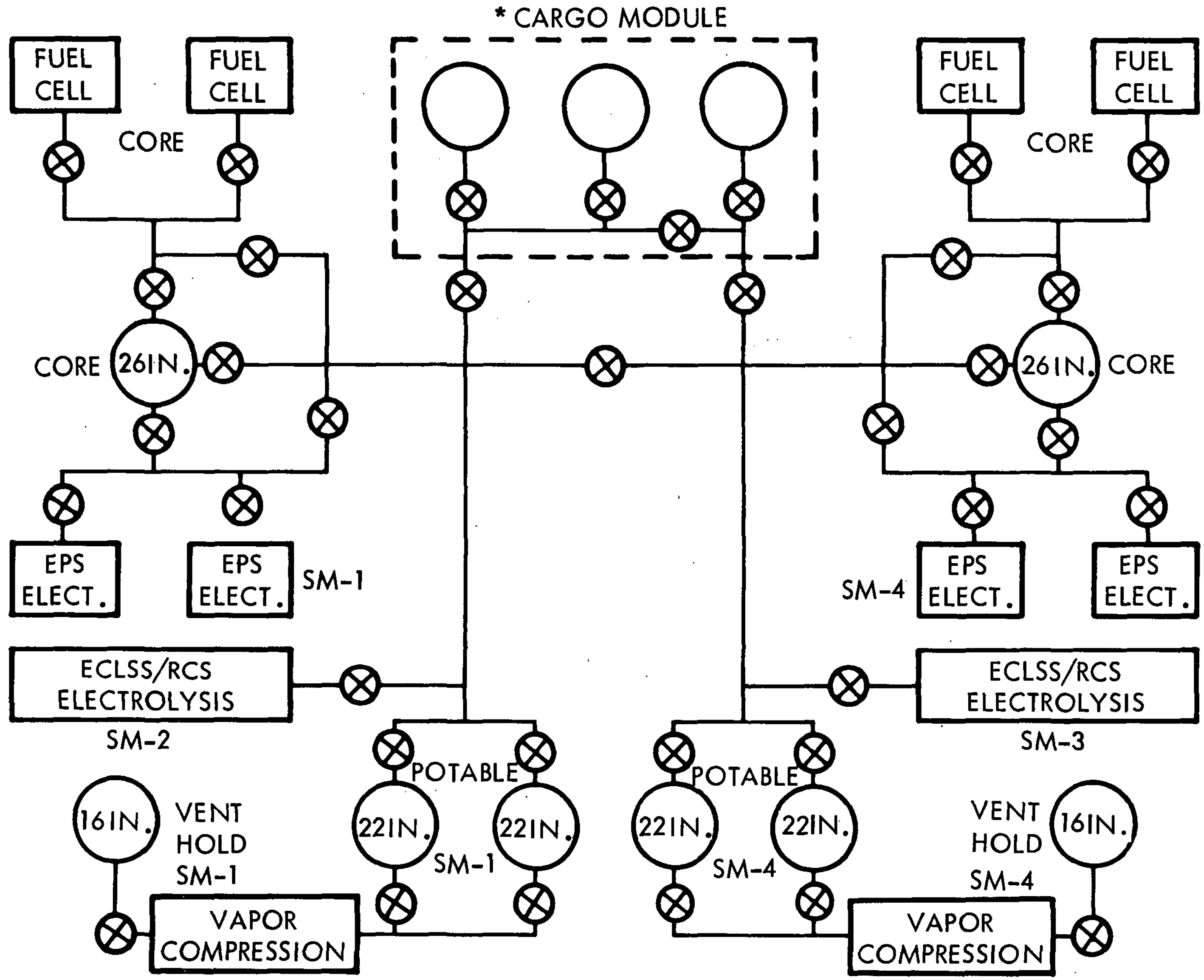


Figure 2.1-9. Water Management Assembly Distribution



*NUMBER AND SIZE OF TANKS IN CM TBD.

Figure 2.1-10. Integrated Water Storage

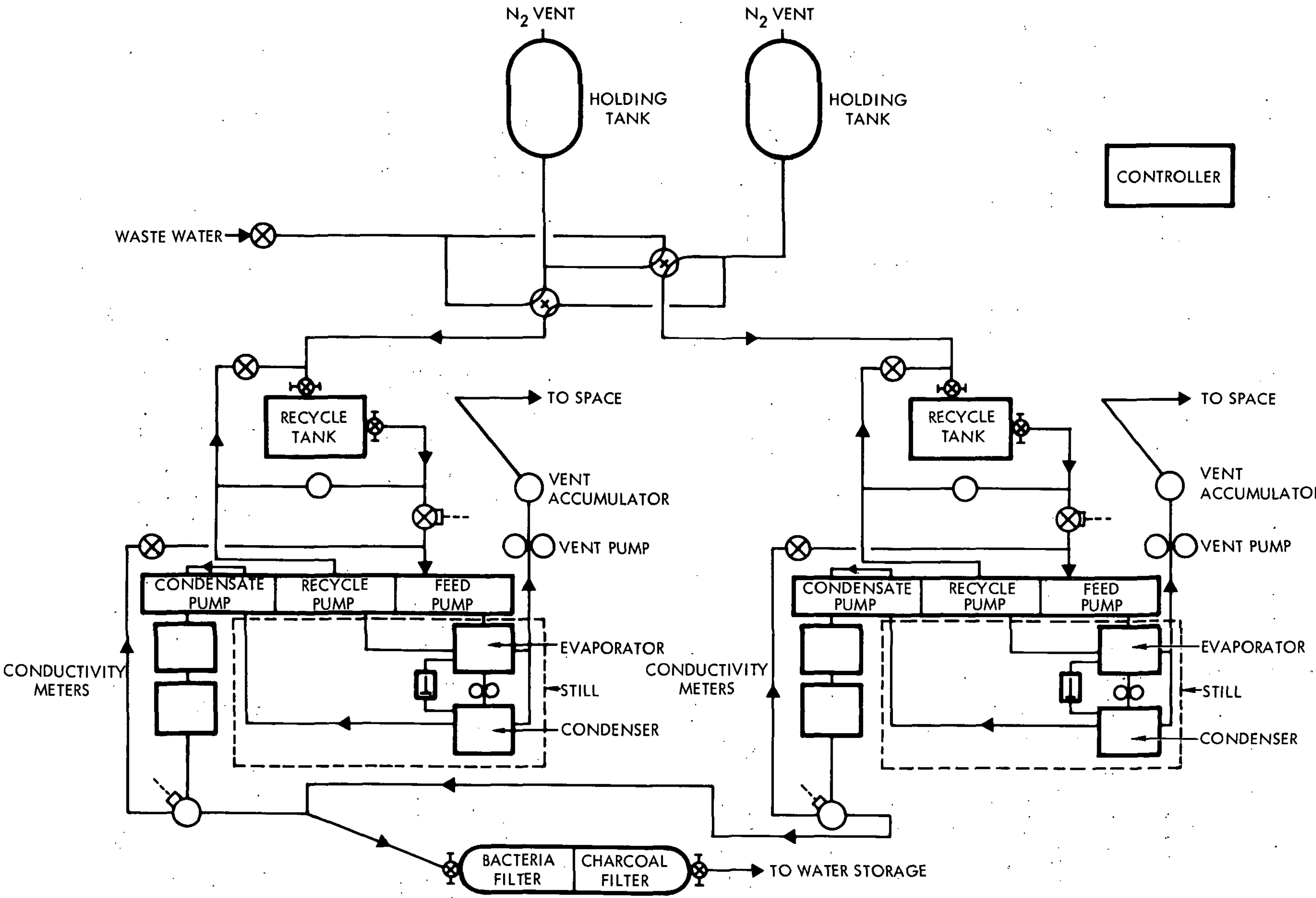


Figure 2.1-11. Water Reclamation Vapor Compression

The subassembly is dependent only upon the power subsystem for proper operation.

When the subassembly is shut down, a dryout process must be performed by shutting off the feed urine before the stills are stopped.

Both spares and expendable replacements are required at each resupply period. Expendables consist of bacteria filter cartridges, charcoal cartridges, solids dryers, and pretreat chemical. The weight of expendables per 180-day resupply period is 242 pounds. The average weight per resupply period for the replacement of random and wear-out failures is 94 pounds.

2.1.1.6 Waste Management

The MSS waste management system is concerned with collection of feces, urine, and trash. Trash collection includes wet trash, experiments trash, sterilize waste, and biomedical waste.

The waste management system interfaces with the water management assembly as indicated in Figure 2.1-11. A schematic representation of the waste management system is shown in Figure 2.1-12. The urine, fecal material, and atmospheric odor/vapor control is shown in the figure. Trash collection utilizes a compactor not shown in the figure.

2.1.1.7 Hygiene Assembly

The hygiene assembly is schematically shown in Figure 2.1-13. The figure shows that this assembly is comprised of the shower, sink, and housekeeping aids. The shower and sink waste water are reclaimed as previously described. The location of the shower and distribution of the four sinks is shown in the figure. Water vapor in the atmosphere is separated and air from the shower is directed back to the atmospheric control system. Air flow through the sinks is sent back to the cabin air return.

2.1.1.8 Special Life Support

The special life support system is made up of the fire control, IVA and PLSS support. The fire control system provides fire detection and control, which interfaces with the logic/alarm/display of the ISS. IVA support consists of a supply for 20 man-hours of O_2, maintenance of heat load, and suit pressure and liquid cooling garment (LCG) water flow. EVA (PLSS) support includes O_2 and water recharge for one two-man EVA per month.

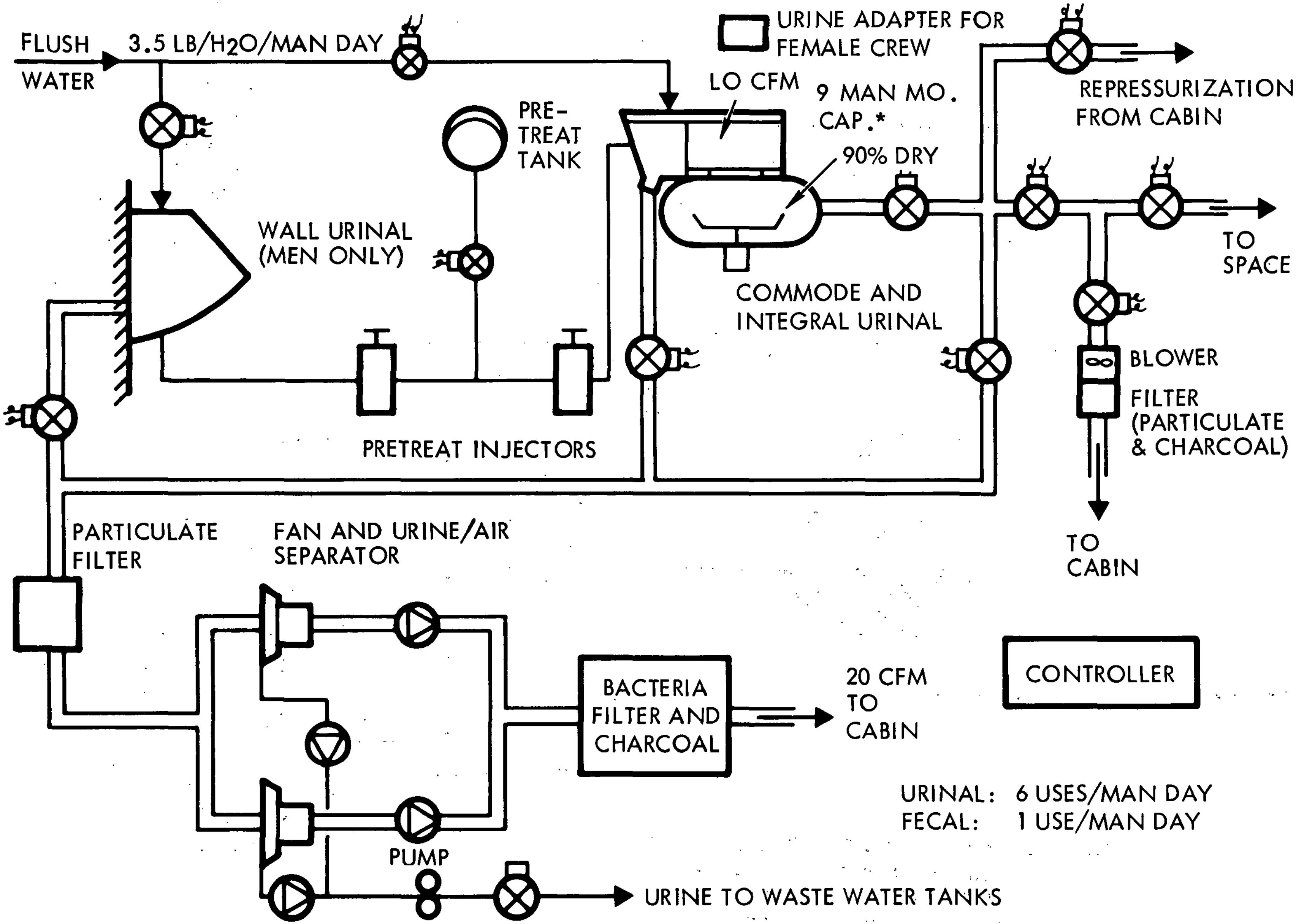
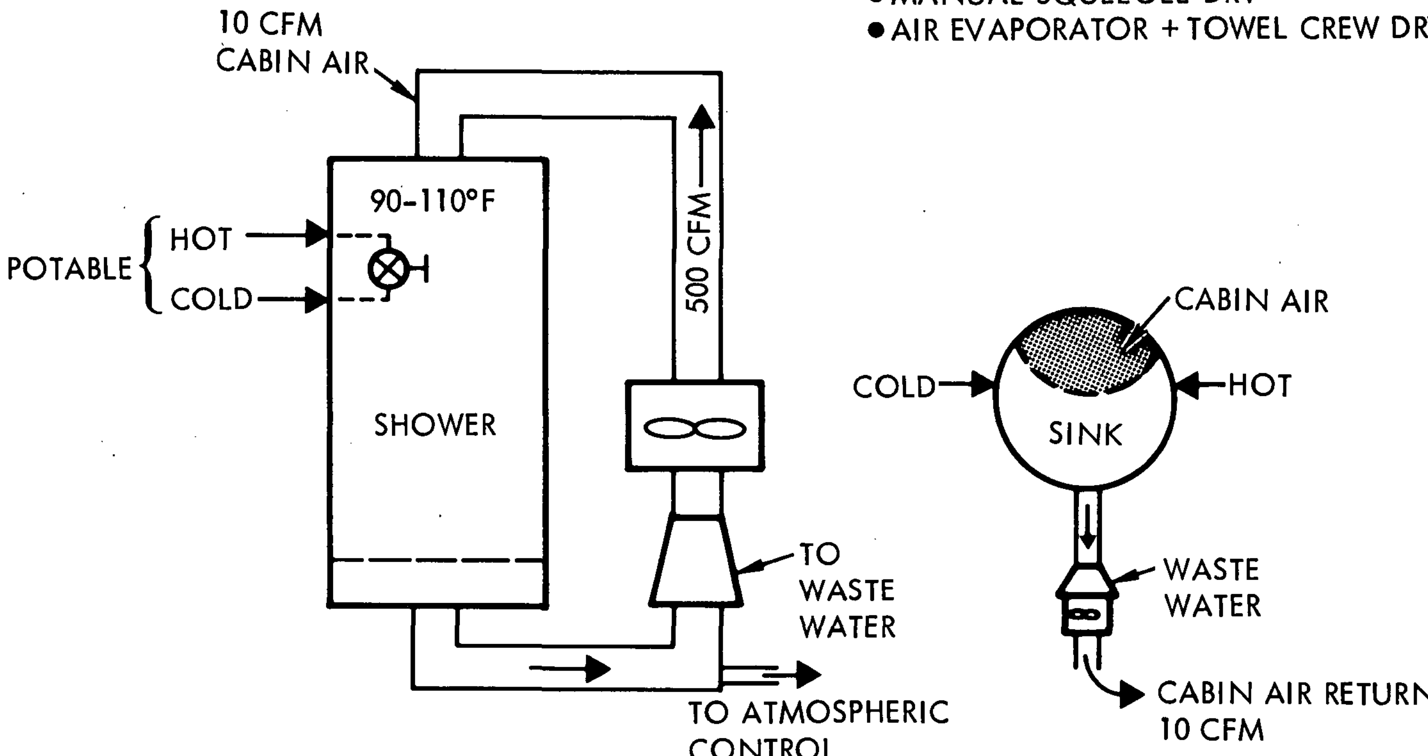


Figure 2.1-12. Waster Management Fecal and Urine Collection

- RECYCLE CAPABILITY FOR VARIABLE SHOWER TIME
- THREE SHOWERS IN SUCCESS MAXIMUM FOR ANY 24-HOUR PERIOD
- MANUAL SQUEEGEE DRY
- AIR EVAPORATOR + TOWEL CREW DRY



INSTALLATION
- ONE SHOWER - SM-1
- FOUR SINKS
  MEDICAL
  GALLEY
  HYGIENE 1
  HYGIENE 2

HOUSEKEEPING AIDS

Figure 2.1-13. Hygiene Assembly

The emergency CO_2 removal also is part of the special life support system. This is accomplished by utilizing lithium hydroxide (LiOH) canisters latched in the air duct system. Figure 2.1-14 is a schematic of the special life support system.

2.1.2 ELECTRICAL POWER SUBSYSTEM (EPS)

The EPS and its subsystems are shown in Figure 2.1-15. The numbers by each subsystem box in the figure refer to the paragraph numbers of the subsystem descriptions provided in this section.

The location of major EPS equipment items is given in Figure 2.1-16 for the initial station. The growth station will utilize two additional fuel cells and two electrolysis units, all located in the short core module.

A functional block diagram of the EPS is shown in Figure 2.1-17; for simplicity, only one of the four identical channels is shown in the figure.

2.1.2.1 Primary Power Generation

The primary power generation subsystem is comprised of the solar array and the orientation drive and power transfer (ODAPT) unit.

The solar array has a normal output performance capability of 47.0 kilowatts (80°C). This output is transferred across slip rings of the ODAPT unit (at 37 amperes and 125 vdc) to inverters and electrolysis units of each of the four channels of the station. From the inverters, power is transferred to the four primary busses. The solar array power input to the electrolysis units is used, obviously, to disassociate water into H_2 and O_2 for other uses within the station.

The solar array operates in 2 degrees of freedom, pitch θ, and roll ϕ for optimum orientation for solar energy impingement. The initial station array has a power-producing area of 8000 square feet while the growth station array, which later replaces the initial station unit, has an area of 10,000 square feet. Each array will utilize a four-panel deployable configuration.

2.1.2.2 Secondary Power Generation

The secondary power generation utilizes the fuel cells, heat rejection, and H_2/O_2 storage tanks. The heat rejection was assigned to ECLSS along with the supply of emergency reactant storage tanks, both of which are discussed in the ECLSS section, paragraph 2.1.1.

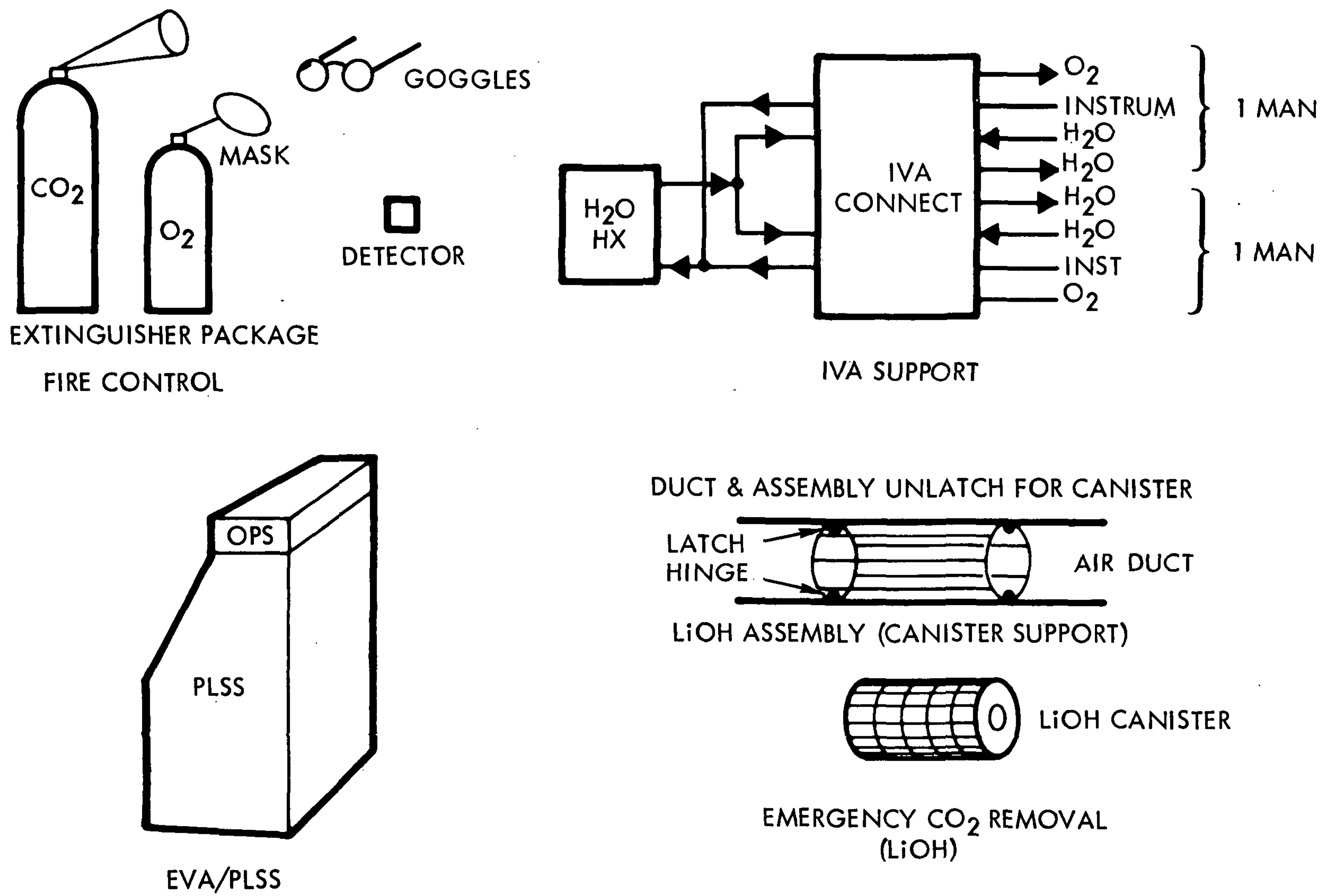
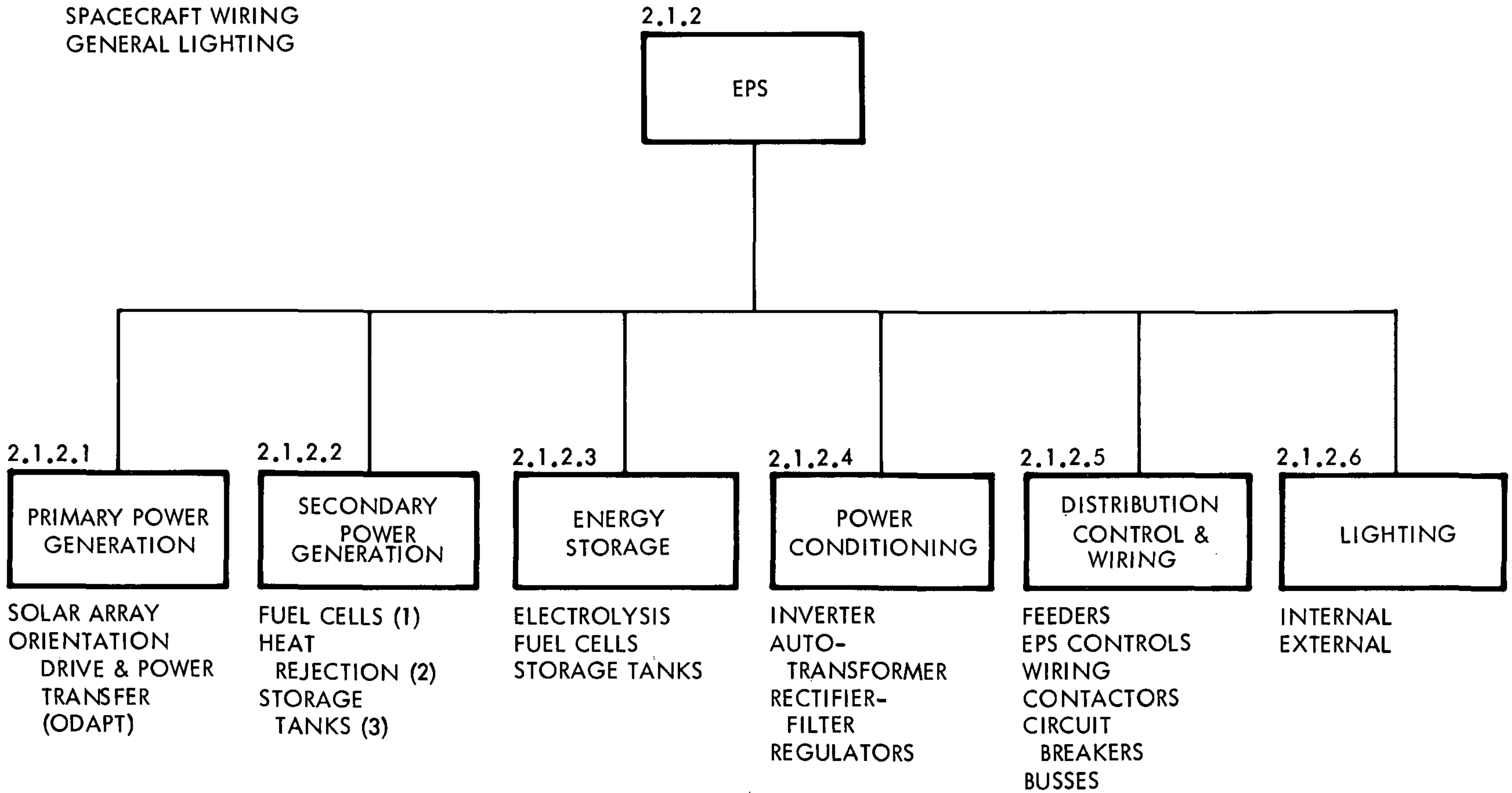


Figure 2.1-14. Special Life Support

SCOPE

ELECTRICAL POWER GENERATION
- PRIMARY POWER GENERATION — NORMAL OPERATIONS
- SECONDARY POWER GENERATION — BUILDUP AND EMERGENCY

POWER TRANSFER AND CONDITIONING
POWER DISTRIBUTION
ENERGY STORAGE FOR ORBITAL DARK POWER
SPACECRAFT WIRING
GENERAL LIGHTING



(1) ENERGY STORAGE FUEL CELLS UTILIZED IN SECONDARY POWER GENERATION
(2) ASSIGNED TO ECLSS
(3) EMERGENCY REACTANT SUPPLIED BY ECLSS

Figure 2.1-15. Electrical Power Subsystem (EPS)

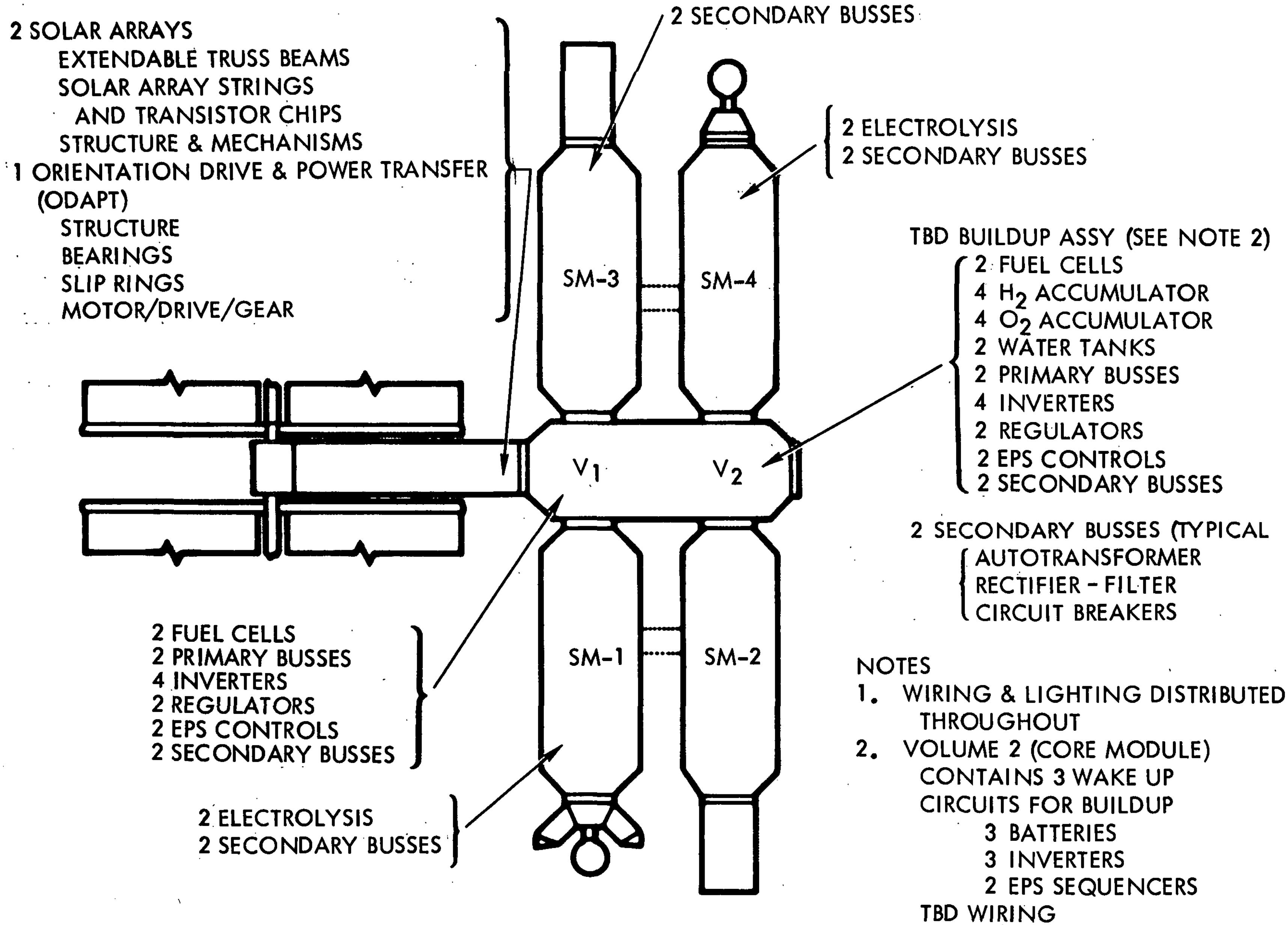


Figure 2.1-16. Location of Major EPS Equipment

- TWO DIFFERENT ENERGY SOURCES
- 4 SOLAR ARRAY CHANNELS
- 4 PRIMARY BUSSES
- 12 SECONDARY BUSSES
- LOCAL EPS CONTROL
- DIFFERENTIAL CURRENT (ISOLATION OF BUSSES TO OPERATE IN ABSENCE OF ISS)
- CENTRALIZED EPS CONTROL
  - PARALLEL OPS OF INVERTERS
  - OPTIMIZED LOAD MANAGEMENT
  - IDENTIFICATION OF IFRU'S
  - SOLAR ARRAY ORIENTATION
  - LIGHTING CONTROL
  - VOLTAGE REGULATION
  - FAULT INTERRUPTION
  - ENERGY STORAGE

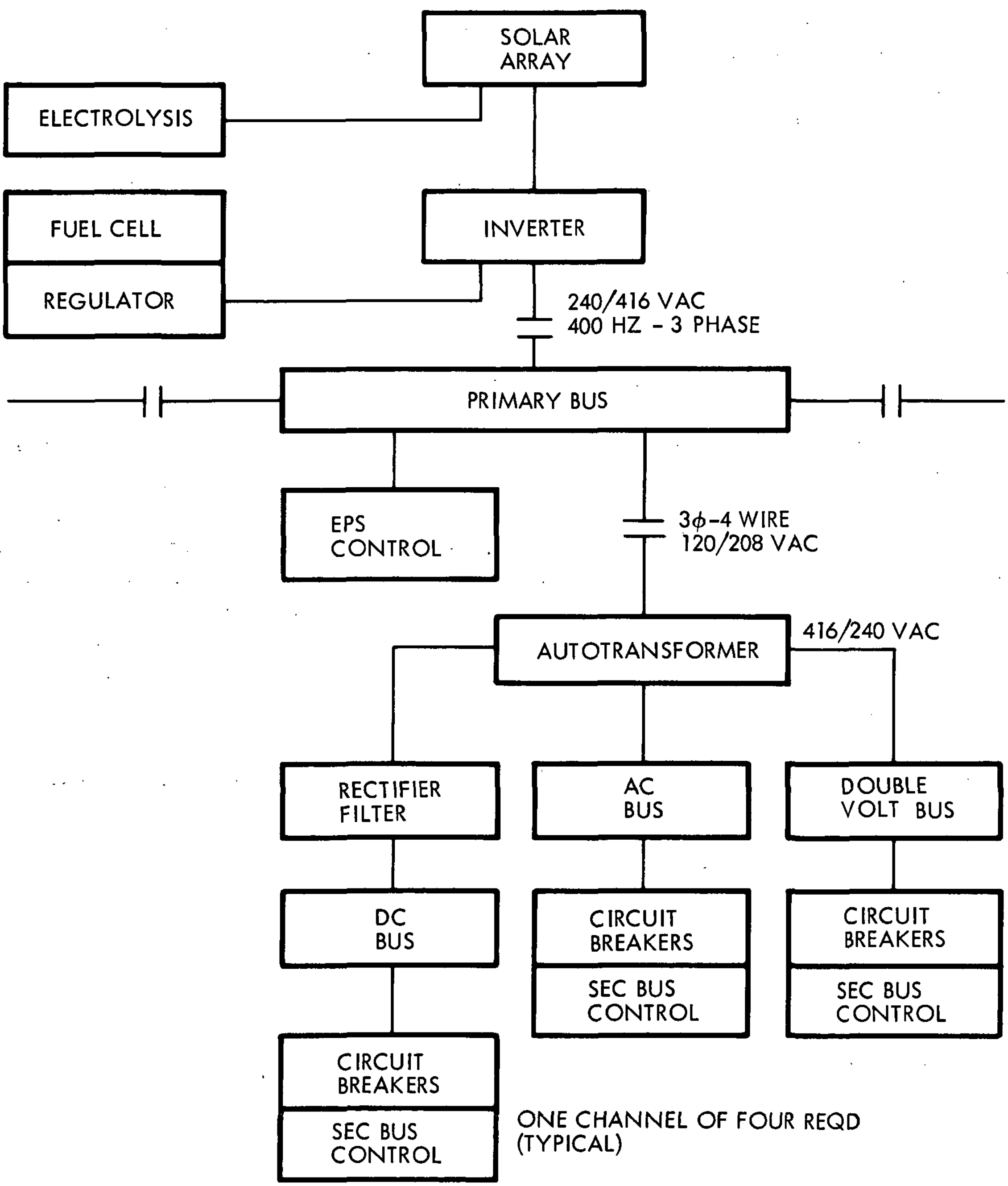


Figure 2.1-17. EPS Functional Block Diagram

The four fuel cells of the EPS, like the solar array source, tie into each of the inverters of the four channels, forming the secondary power source feeding the primary busses. The fuel cells each have a rated power output of 7.0 kilowatts and supply a regulated voltage to the inverters.

2.1.2.3 Energy Storage

The electrolysis units, fuel cells, and H_2/O_2 accumulators (storage tanks) comprise the energy storage system. Regenerative fuel cells (described previously) utilize H_2 and O_2 produced by the electrolysis of water. The H_2 and O_2 gases generated by the electrolysis process are stored in their respective accumulators in the core module.

There are four H_2, 33-inch-diameter and four O_2, 27-inch-diameter accumulators located in the core module.

2.1.2.4 Power Conditioning

The inverters, autotransformers, rectifier-filters, and regulators all belong to the power conditioning system.

The inverters accept the dc voltage inputs from the fuel cells or the solar array at ±125 vdc and convert it to 240/416 vac, 400 Hz-3-phase. This output of the inverters is fed to the four primary busses. The autotransformers accept these primary bus voltages and convert them into three separate voltage categories. These voltages feed the four core module 56-vdc secondary busses and each of the other modules' secondary busses (two each) with 3-phase-4 wire 120/208 vac and 240/416 vac-3-phase. The 56-vdc output results from passing the autotransformer output through a rectifier-filter network.

Voltage regulators are used between the output of the fuel cells and the inverters powering the primary busses.

2.1.2.5 Distribution Control and Wiring

Feeders, controls, wiring, contactors, circuit-breakers, and busses comprise the distribution control and wiring system.

The distribution system is made up of four primary busses, two in each volume of the core module and 12 secondary busses, two in each volume of the core module, and two in each of the other four modules.

The primary busses are fed with 240/416 vac 400-Hz, 3-phase, and the secondary busses are fed 240/416, 120/208 vac 400 Hz, 3-phase and 56 vdc. The distribution of the primary and secondary busses is shown in Figure 2.1-16.

The EPS control is divided into two parts: (1) local control which deals with voltage regulation start up and independent bus operation (isolated) in the event of fault interruption and of absence of ISS, and (2) centralized control, which is concerned with parallel operation of inverters, voltage regulation, fault interruptions, energy storage, optimized load management, solar array orientation, and lighting control. The EPS control ties in to the primary busses as indicated in Figure 2.1-17.

2.1.2.6 Lighting

The lighting system of the MSS pertains to interior and exterior lighting. Interior lights throughout the MSS will satisfy the crew habitability intensity requirements. The MSS external lights will be such that a rendezvousing vehicle can visually determine the station orientation at 2000 feet. Lights will be mounted on the forward and aft ends of the MSS and at the ends of extreme projections.

2.1.3 GUIDANCE AND CONTROL (G&C)

The G&C subsystem consists of the assemblies shown in Figure 2.1-18. The paragraph numbers indicated in the figure refer to the corresponding description paragraph number in this section. A functional block diagram of the G&C subsystem is provided in Figure 2.1-19, which shows the guidance and navigation along with the stabilization and control functions the subsystem performs.

The guidance and navigation relates to the autonomous station navigation and orbit maintenance guidance. Stabilization and control pertains to operational modes, such as local level for experiment activities, minimum fuel mode with shuttle attached, inertial, and operation without jets for a minimum of six orbits.

2.1.3.1 Inertial Reference Assembly

The inertial reference assembly contains six strapdown gyros for sensing station instantaneous angular rates and six accelerometers for sensing station instantaneous linear accelerations. These sensing elements are arranged in a nonorthogonal skew axes orientation in the strapdown inertial measurement unit that is mounted to the navigation base. This orientation allows the inertial reference preprocessor to provide body orientation and changes in velocity to the ISS with three gyros and three accelerometers failed.

SCOPE

- STATE VECTOR DETERMINATION & GUIDANCE COMMANDS
  - STATION
  - FREE FLYING RAMS
- STATION CONTROL
  - ATTITUDE HOLD
  - MANEUVERS

HARDWARE

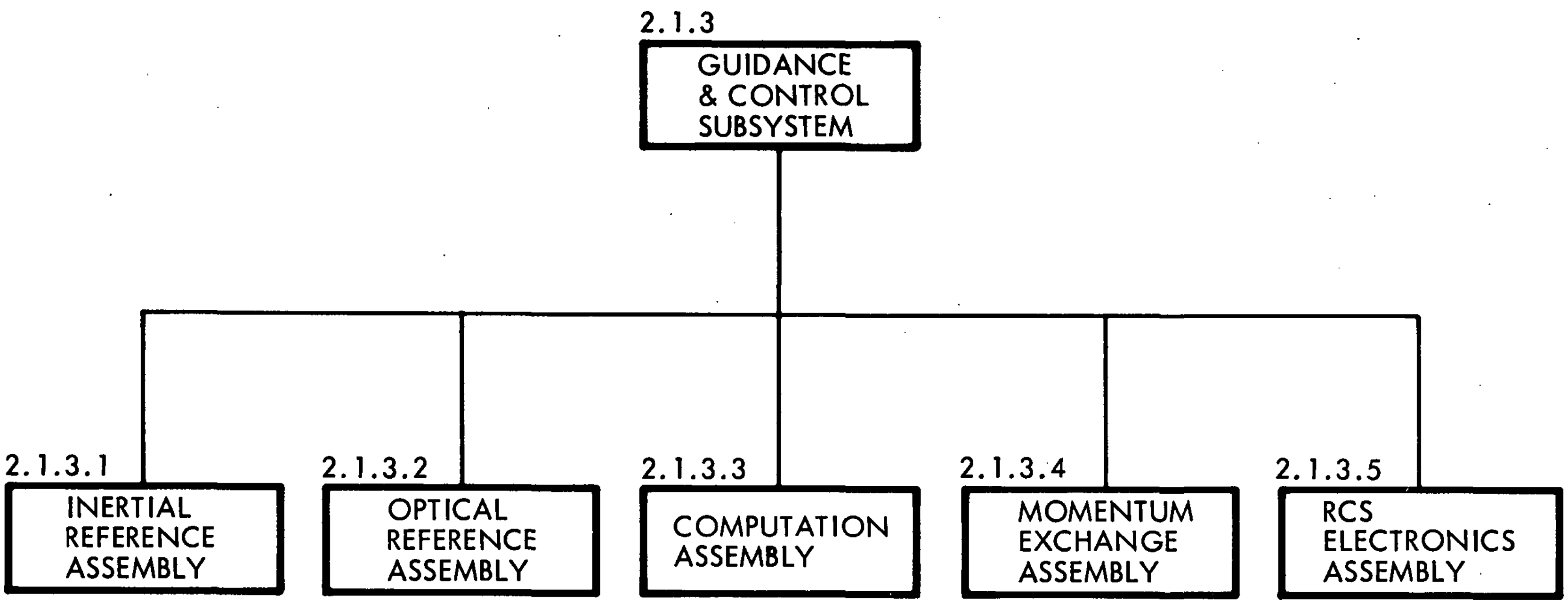


Figure 2.1-18. Guidance and Control Subsystem (G&C)

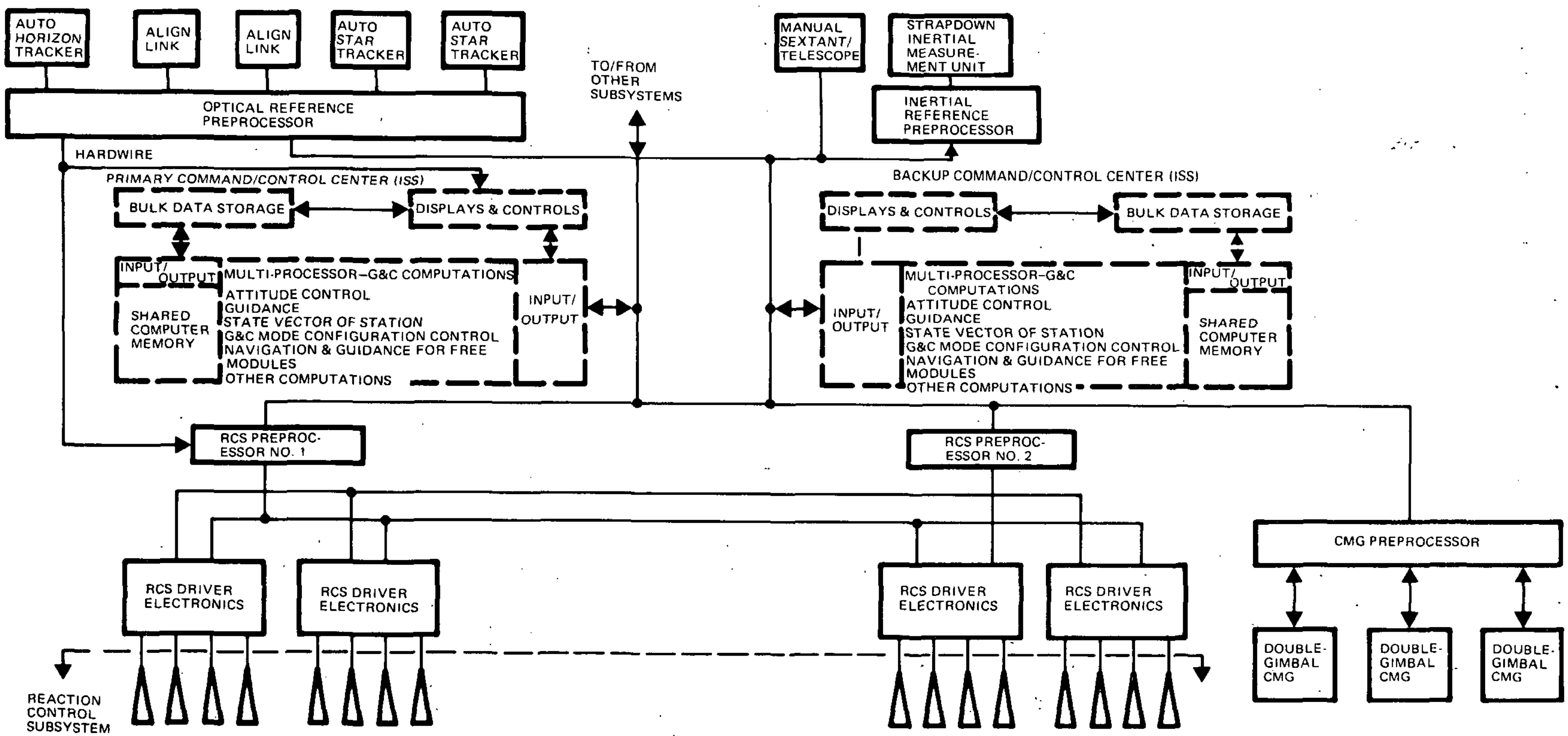


Figure 2.1-19. G&C Functional Block Diagram

The preprocessor provides changes in station body axes orientation and changes in velocity to the ISS for relating present station orientation and location with the reference frame being maintained by the ISS computer and for use in attitude control and orbit maintenance.

2.1.3.2 Optical Reference Assembly

The optical reference assembly contains one 4-head, horizon edge tracker and associated electronics for simultaneous viewing of four horizon quadrants and two star trackers for providing automatic sensing of the horizon and of star angles. The outputs from these sensors are utilized by the optical reference preprocessor in providing star and horizon angles and pitch, yaw, and roll attitude errors to the ISS computer for use in maintaining the station state vector and the desired flight mode.

The telescope and sextant unit is mounted to the navigation base to relate manual optical sightings to the station attitude. The telescope and sextant unit provides a means of initializing the automatic navigation reference. It also provides direct visual observation of earth targets in support of experiments.

Two three-axis autocollimator alignment links are used for navigation base alignment.

The optical reference assembly preprocessor is the interface with the ISS computer in performing optical assembly computations.

2.1.3.3 Computation Assembly

Those guidance and control computations not performed in the preprocessor described in the other assemblies are performed within the ISS computer. The computation assembly represents the software associated with the guidance and control computations performed within the ISS computer.

2.1.3.4 Momentum Exchange Assembly

The momentum exchange assembly contains four double gimbal control moment gyros that are oriented in response to commands from the CMG preprocessor to compensate for angular momentum changes caused by periodic disturbance torques. Buildup of residual momentum from nonperiodic torques eventually causes CMG gimbal angles to reach their limit, and the CMG preprocessor provides data to the ISS to determine RCS torque and on-time required for CMG desaturation.

2.1.3.5 RCS Electronics Assembly

The RCS electronics assembly contains the RCS electronics two preprocessors that provide RCS jet driver selection logic and pulse commands to the four jet driver packages which contain 16 RCS jet drivers that also are part of the RCS electronics assembly. The RCS jet drivers provide on-off signals to the reaction control subsystem solenoid valves and igniters.

2.1.4 REACTION CONTROL SYSTEM (RCS)

The reaction control system (RCS) and its subsystems are depicted in Figure 2.1-20. The individual subsystems are described in this section in paragraphs of corresponding number. These three subsystems are the propellant accumulator, propellant feed control, and engines.

The RCS interfaces with three other systems in the station. An interface with the ECLSS exists, because H_2 and O_2 gases are provided by the electrolysis unit. A backup supply of H_2 and O_2 is available from the EPS electrolysis unit, and an emergency source is contained in the cargo module. To access these gases, there is a docking interface with SM-2, SM-3, SM-5, and SM-6, and the core module.

Figure 2.1-21 is a schematic representation of the RCS installations in the various modules for the buildup, initial, and growth station.

2.1.4.1 Propellant Accumulators

The O_2 and H_2 required for the RCS are contained in accumulators located in SM-2 and SM-3 as shown in Figure 2.1-22. There are two pairs of O_2 and H_2 in each module. These accumulators are supplied by the electrolysis unit of the ECLSS and normally operate at a pressure of 300 psi. In an emergency situation, the EPS accumulator can be used as a source of gas.

On the growth station, an additional pair of accumulators will be located in SM-5 and in SM-6.

All of the O2 accumulators are 13 inches in diameter, and the H2 tanks are 16 inches in diameter.

2.1.4.2 Propellant Feed Control

Propellant feed control is comprised of the tubing, valves, regulators, and relief valves that transfer the gases from the accumulators to the engines with the proper pressure reduction and flowrate.

SCOPE

PROVIDE THRUST FOR

- STABILIZATION & CONTROL
- CONTROL OF DOCKING TORQUES
- ORBIT MAINTENANCE
- CMG DESATURATION
- MANEUVERS

PROVIDE STORAGE FOR ECLSS H2 & O2 FOR SABATIER & HYDROGEN DEPOLARIZER OPERATION AND O2 METABOLIC DURING ORBITAL DARK OPERATIONS

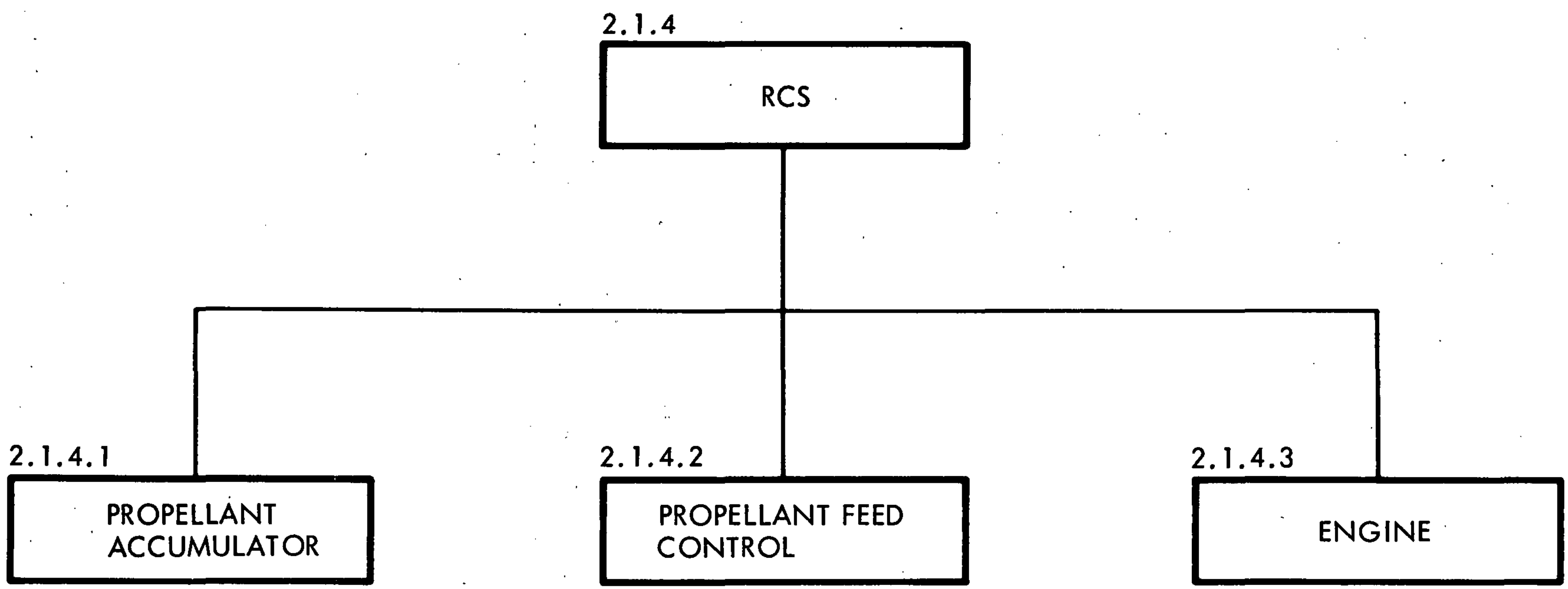


Figure 2.1-20. Reaction Control System (RCS)

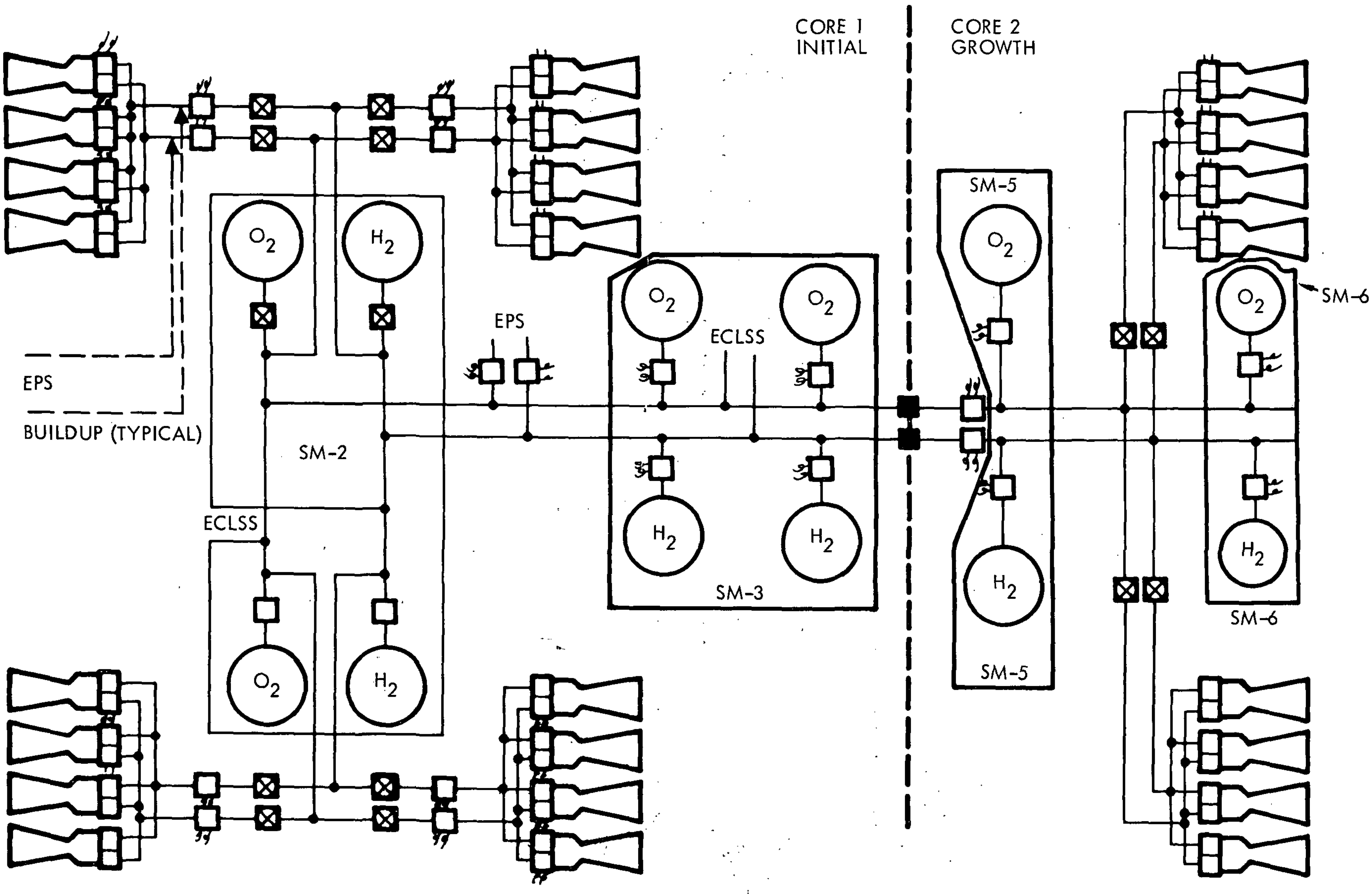


Figure 2.1-21. RCS Schematic

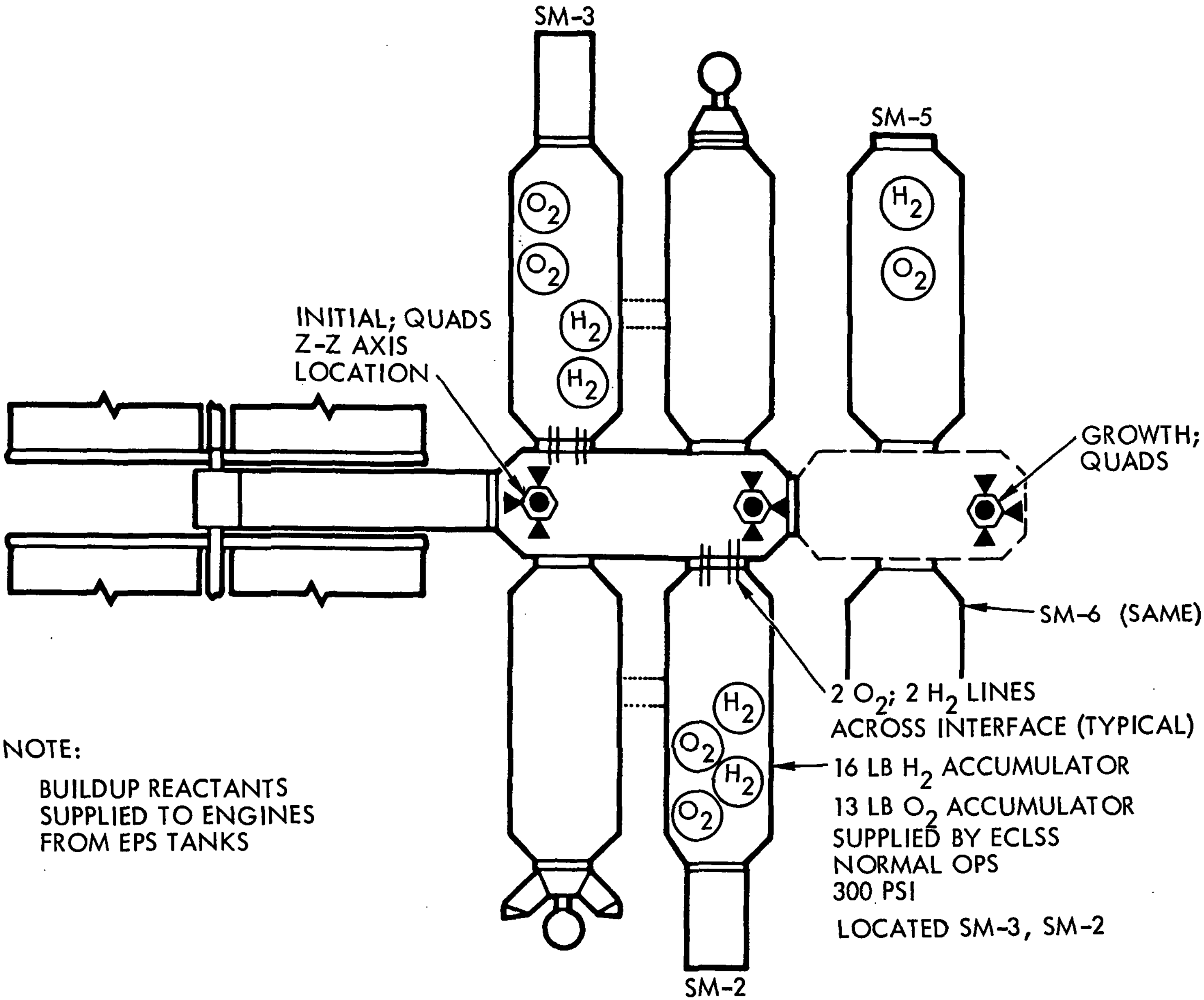


Figure 2.1-22. RCS Equipment Location

2.1.4.3 Engines

The engine quads are located on the Z-axis of core 1 for the initial station. For the growth station, additional quads will be on the short core. These engines provide the necessary thrust station stabilization, orbit makeup and CMG desaturation, maneuvering, and docking torque.

Each of the engines develops 10 pounds of thrust and uses an oxygen-to hydrogen ratio of 8 to 1, with an I_{SP} of 320 seconds.

2.1.5 INFORMATION SUBSYSTEM (ISS)

The ISS in the modular space station consists of all the hardware and software necessary to provide the following capabilities:

1. Communications between MSS to and from the space shuttle, detached RAM's, ground complex, and EVA

2. Range and range-rate determination of cooperative targets

3. Internal communications between station modules

4. Primary interface between crew and the subsystem/experiments

5. Automatic control and checkout (manually assisted) of the subsystems

6. On-board management (short-term) of station and experiment activity

The hardware and software required to accomplish these objectives have been grouped into the five assemblies shown in Figure 2.1-23 and will contain the components listed under each assembly.

Although certain components of the ISS are located throughout the MSS, SM-1 and SM-4 contain all the hardware/software required to perform the control function and may in this context be described as the control modules. This hardware allocation is summarized in Figure 2.1-24.

2.1.5.1 Data Processing

The MSS data processing assembly is represented in Figure 2.1-25 in block diagram form. It consists of two data bus control units, two central timing units, two central processors, and 52 RACU's. With the exception of the RACU's, the DPA hardware is divided between SM-1 and SM-4 in such

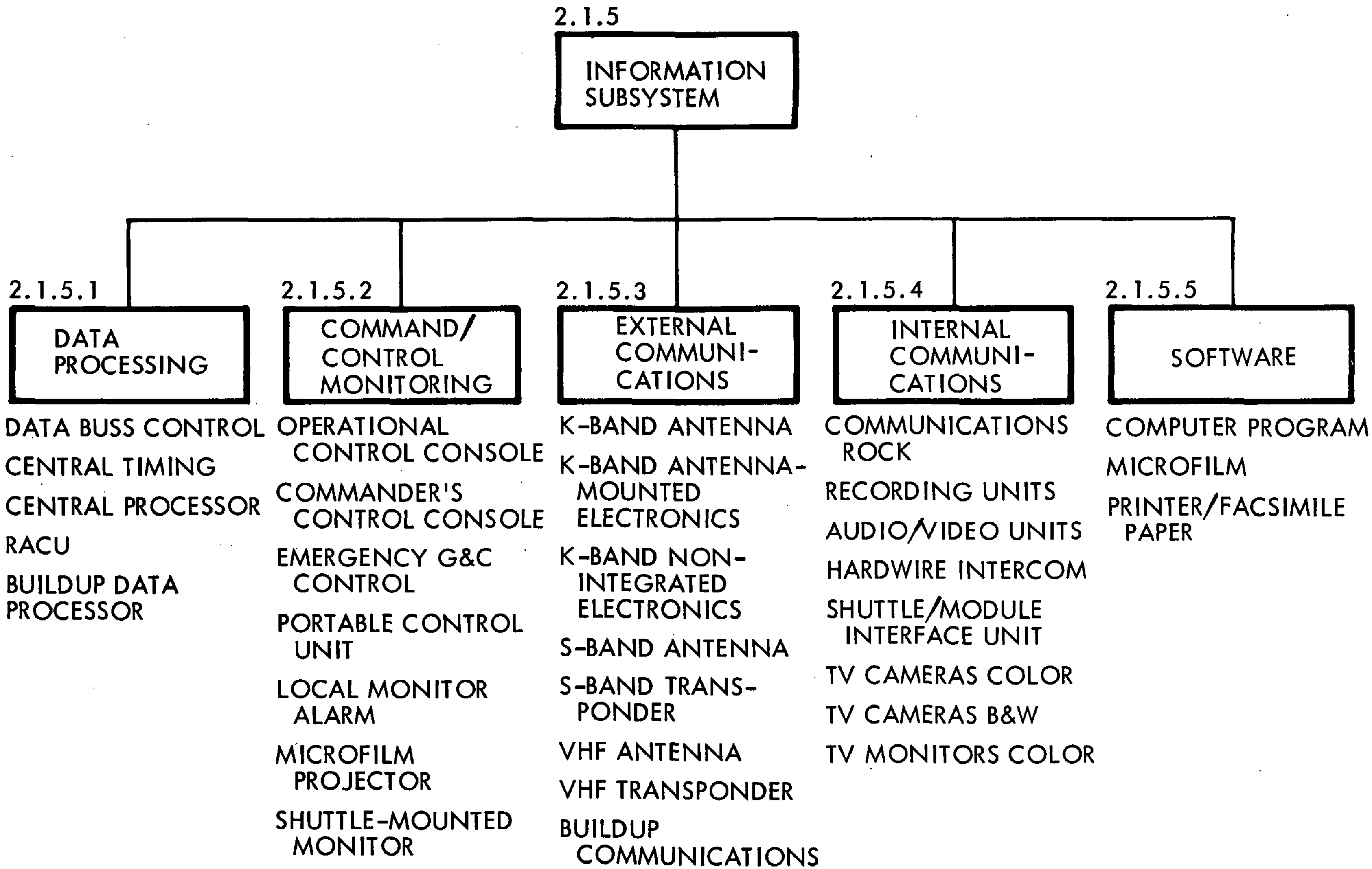


Figure 2.1-23. MSS ISS Definition

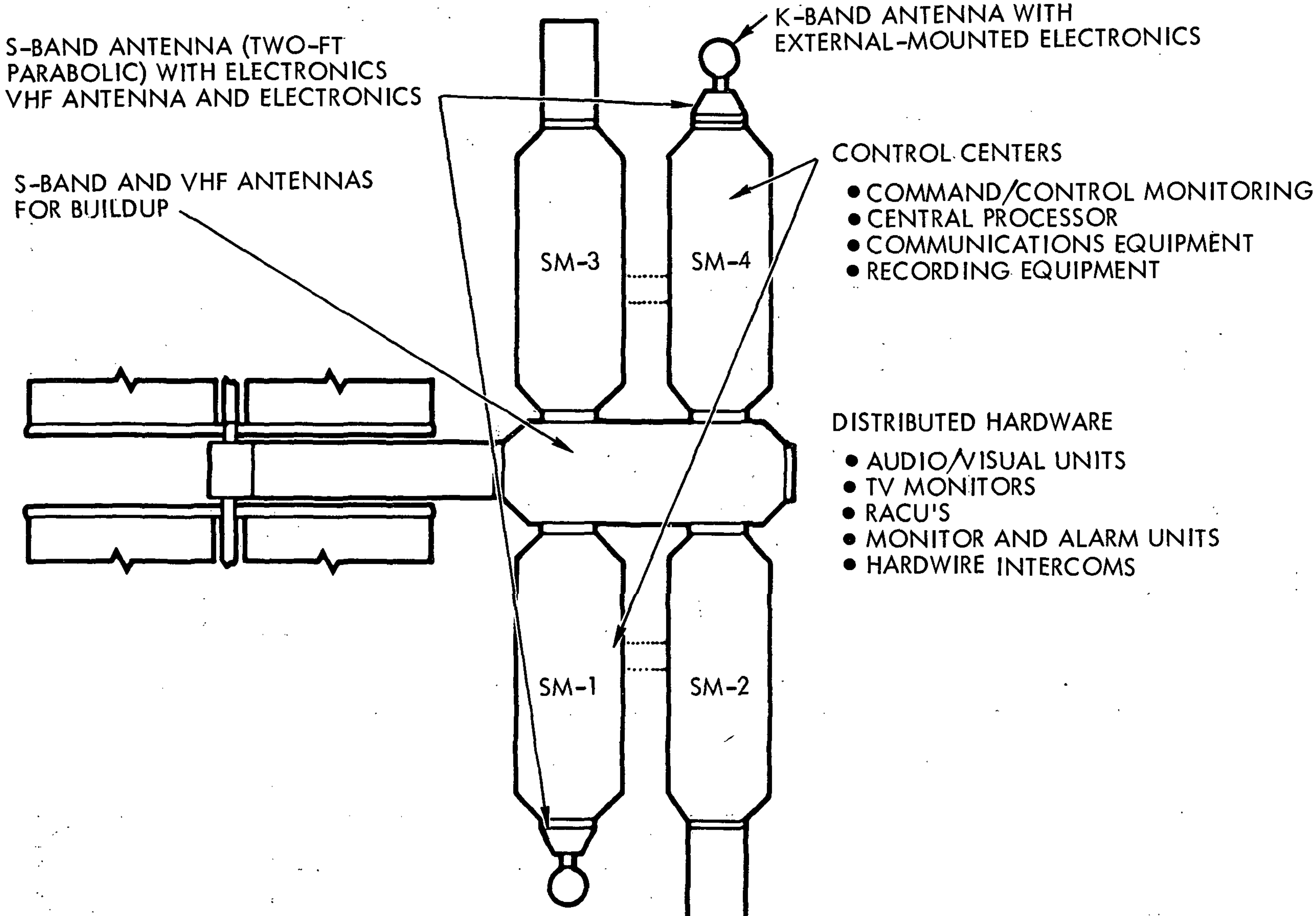
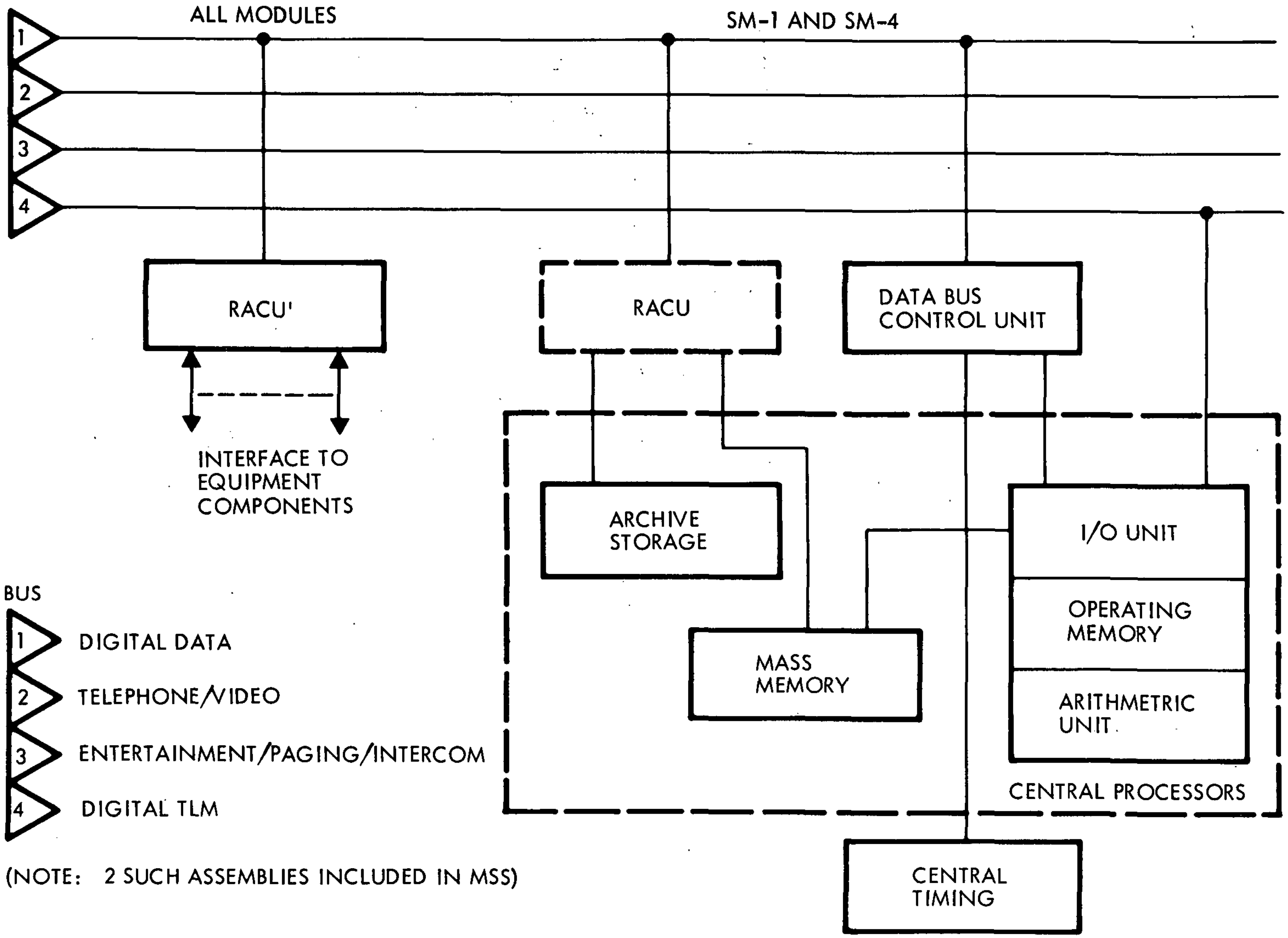


Figure 2.1-24. Locations of Major ISS Components



(NOTE: 2 SUCH ASSEMBLIES INCLUDED IN MSS)

Figure 2.1-25. Data Processing Assembly

a manner as to provide two control stations each capable of performing the MSS control function and thereby provide redundant capability in case of ISS failure. Implied in the hardware distribution outlined is the concept of a centralized DPA system.

The central processor will provide information processing services (i.e., computation and data acquisition and distribution). It consists of two multiprocessors interconnected via the data bus in the backup mode described previously. In addition to its operating memory, the central processor will be provided with mass and archival memory.

Subsystem commands and function performance requests resulting from processing in the central processor will be transmitted to the remotely located RACU's, where the requests and commands will be decoded and converted into 5-volt discrete or 0- to 5-volt analog commands.

In the response mode, RACU's will receive data responses from the subsystems and will convert them into coded formats appropriate for transmission over the data bus to the central processor.

The data processing assembly also includes a central timing unit that is used for navigation reference, for processing timing, and for electrical power frequency control. The timing units will utilize a rubidum atomic timer. Two units will be used, one in each of the control modules.

Performance characteristics for the hardware described are given in Table 2.1-1.

2.1.5.2 <u>Command/Control Monitoring</u>

The man-machine interface for the MSS ISS will be provided by the command and control and monitoring assembly. Figure 2.1-26 depicts the major components and their connections to the ISS information distribution lines.

The control consoles are connected to the digital data bus through RACU's in the same manner as the other hardware in the MSS. There are two operations control consoles (one in each of the control center modules), one commander's control console in SM-4, and three portable control units that may be connected to the data bus at various locations in the station.

The two operations control consoles are normally assigned the separate roles of station and experiment control and monitoring. These consoles are illustrated in Figure 2.1-27. They consist of a multiform/callable display (CRT, light-emitting diodes) and a typewriter-type input keyboard.

Table 2.1-1. Data Processing Assembly Performance Characteristics

Central processor (CP)	Computation speed			1×10^6 EOPS
	Word size			32 bits
	Memory			
		Operating	Mass	Archive
	Words	144×10^3	704×10^3	682.6×10^3
	Access time	<0.5μS	<2μS	>1 minute
	No. of modules	9	4	
	Module size	16,000	176	
Remote acquisition control unit (RACU)	Data bus rate			2.8×10^6 bps
	Words memory			4000 (32-bit word)
	Input from equipment			
				Digital/Discrete
	Quantity	100/28		28/100
	Input range (vdc)	0 to 5		0 or 5
	Input type	Single-ended		Single-ended
	Input impedance	1 MΩ		1 MΩ
	Source impedance	1 KΩ		1 KΩ
	Output to equipment			
		Digital (Parallel)		Digital (Serial)
	Quantity	24		8
	Output type	On/off parallel single-ended		On/off serial
	Output level	Logic "1" 3.6 ± 1.2 vdc Logic "0" 0.2 ± 0.02 vdc		
Central timing unit (CTU)	Basic frequency			10 MHz
	Stability			2 parts per 10^8
		Divide to operating frequencies as required		
Data bus control	Type	Bidirectional		
	Data bus rate	2.8×10^6 bps (10-M capability)		
	Data bus code	Biphase shift Modulation		
Digital data bus	10 mbps			
Telephone/video	Total bandwidth		42 MHz	42 MHz
			12 voice channels	
			6 video (one time-shared with voice)	
Entertainment/paging/intercom	High fidelity	1 channel		
	Paging/alarm override	1 channel		
	Voice grade	N channel		
Digital telemetry	Interconnects central processor with modulation processor			
	Dual twisted pair			
	Capability			
	Experiment TLM	2.0 Mbps		
	Station operations	0.5 Mbps		
	Recorder TLM	0.5 to 5 Mbps		
	Uplink computer data	0.5 Mbps		

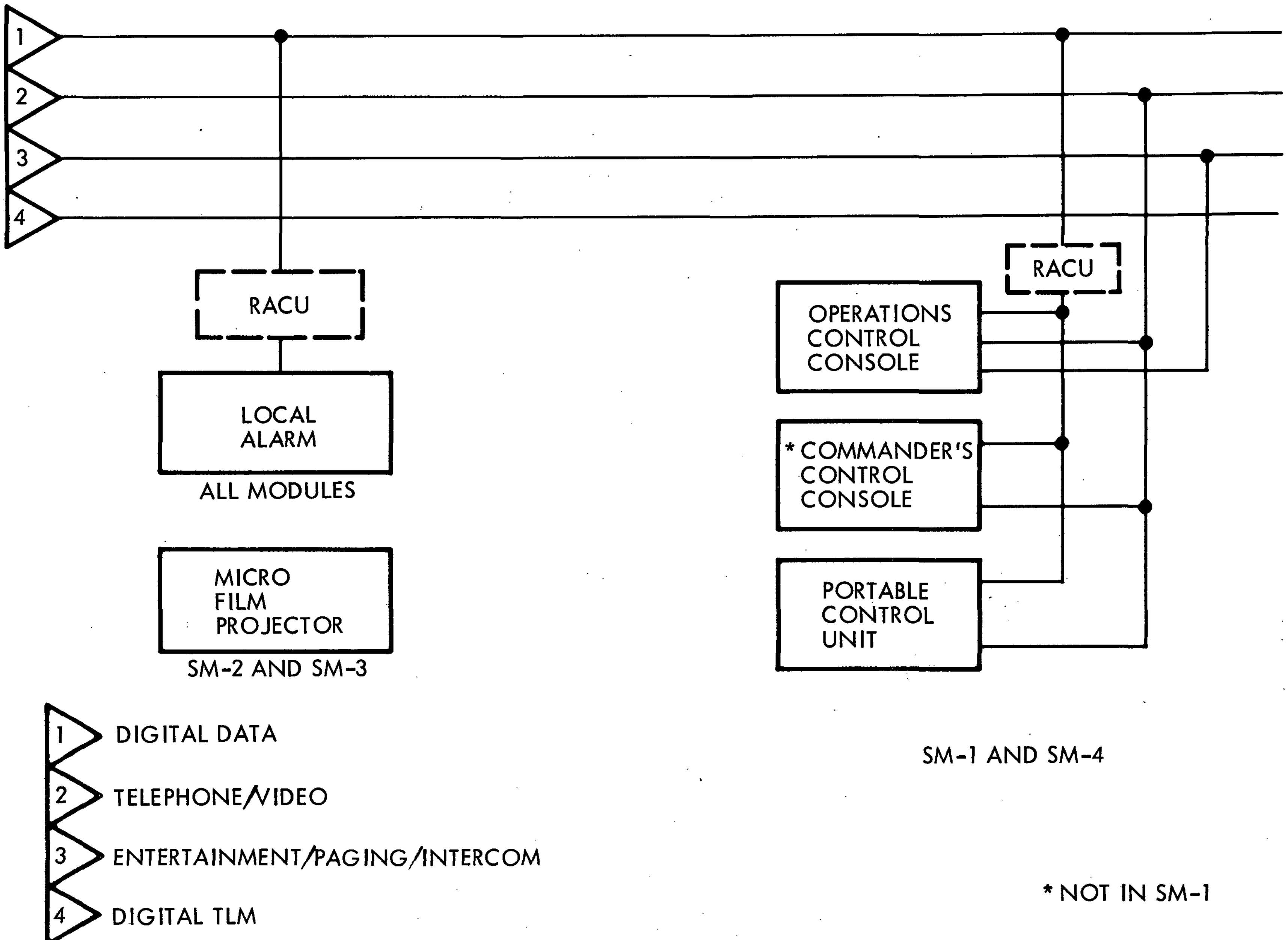


Figure 2.1-26. Command Control and Monitoring

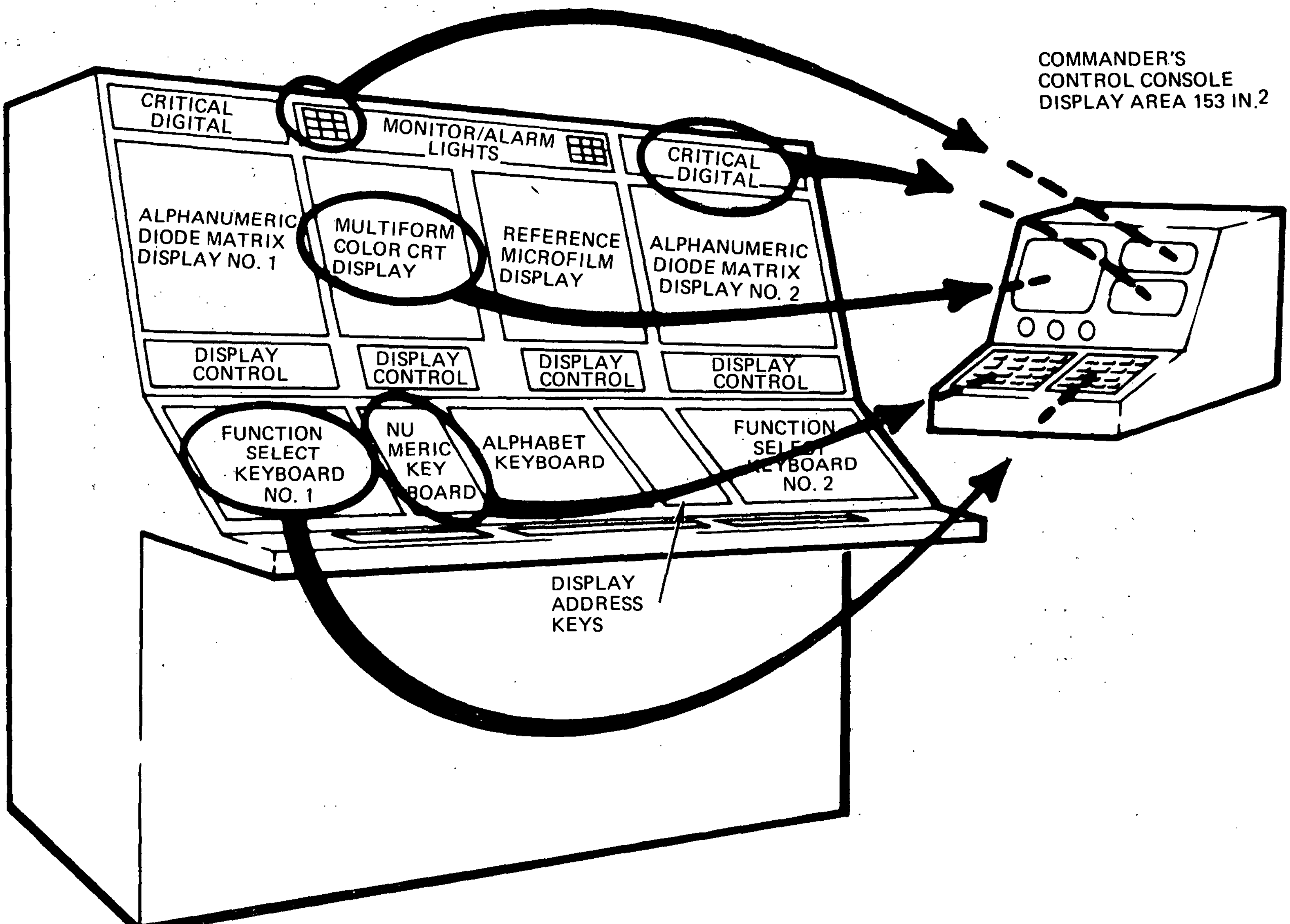


Figure 2.1-27. Commander's Control Console MSS ISS Definition

The commander's control console located in the commander's stateroom provides the commander with access to the DPA functions and serves as a backup control station. It is a small version of the operations control console as indicated in Figure 2.1-27.

In addition to the control units already mentioned, there will be three portable control units that will be used for maintenance and troubleshooting activities; when necessary, these units also may be used for backup station control and experiment operations.

A fourth type of control is provided in the form of special G&C emergency control unit hardwired to the RCS electronics. This unit provides on-off controls and status for emergency situations. One each is provided in the pressure volumes of the core module.

Local monitor and alarm units will be provided at each of the station modules to repeat alarm displays appearing in the operational control console.

Microfilm projectors for displaying 16mm film will be used to display reference imagery and maintenance data. These units will be located in the GPL and in modules SM-1 and SM-4.

Performance characteristics for the equipment previously described are given in Table 2.1-2.

2.1.5.3 External Communications

The MSS external communications system consists of three RF links as illustrated in Figure 2.1-28. The primary link to the ground is provided by the K-band system. It consists of inboard-mounted S-band receiver and transmitters and auxiliary electronics and outboard-mounted 5-foot parabolic antennas with S-band conversion electronics mounted on the antennas. There is one parabolic antenna mounted at the end of each of the control modules (SM-1 and SM-4); their orientation is controlled to provide continuous real-time communications capability through the TDRS communications system.

The S-band RF subsystem is designed to fulfill two functions: (1) provide primary link to the shuttle and DRAM, and (2) provide a secondary link to the ground.

The primary link to the shuttle and DRAM is achieved through the use of S-band transmitters and receivers mounted inboard in the proximity of two externally mounted semidirective antennas in SM-1. The secondary

Table 2.1-2. Command Control and Monitoring Physical Characteristics

Unit	Characteristic	Space Required (square inches)
Operational control console	Multiform/callable display	297
	Dedicated display	194
	Alphanumeric keyboard	64
	Microfilm display	117
	Function select keyboard	96
	Dedicated control panel	32
	Numeric keyboard	16
	Flight control command device	1
Commander control console	Multiform/callable display	81
	Dedicated display	97
	Alphanumeric keyboard	42
	Function select keyboard	48
	Dedicated control panel	36
Portable control unit	Multiform/callable display	81
	Dedicated display	20
	Alphanumeric keyboard	48
	Function select keyboard	12
	Dedicated control area	36
Emergency G&C control	Near RCS electronics	
	Manual control device	
	One per volume in core with windows	
	Hardwire RCS electronics interface	
Local monitor and alarm	Dedicated displays	48
Microfilm projector	16mm projector (back projection)	

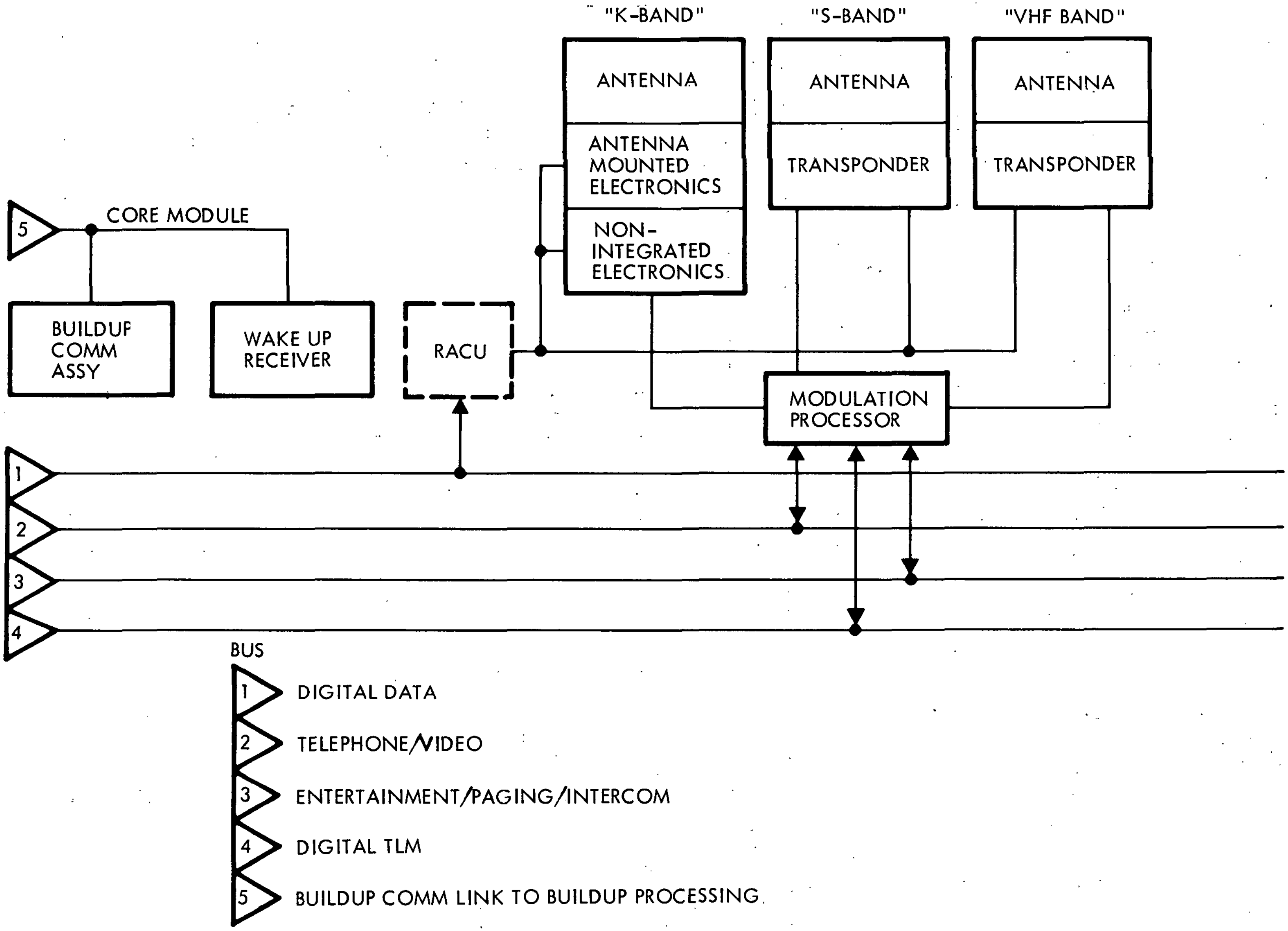


Figure 2.1-28. External Communication, SM-1 and SM-4

link to the ground capability utilizes a more powerful combination of S-band receivers and antennas. These include a 2-foot, fixed parabolic antenna mounted on the end of SM-4.

A VHF-band RF link also is provided as the primary voice EVA link during normal operations. It will consist of two antennas on each end of SM-1 and SM-4 and their associated transmitters and receivers in the pressure volumes next to the antennas. The antennas will be mounted to give unobstructed communications with the TDRS.

Primary performance characteristics for the external communications hardware are given in Table 2.1-3. Antenna locations and coverage are given in Figure 2.1-29.

Table 2.1-3. External Communications Performance Characteristics

Frequency	Characteristics	Performance
K-band 13.4 to 15.35 GHz	RF power Antenna gain Receiver system noise figure Bandwidth	25 watts 45 db 6 db 50 MHz
S-band - fixed parabolic links 2025 to 2300 MHz	Receiver system noise figure RF power Antenna gain Bandwidth Cone coverage	6 db 10 watts 12 db 15 MHz 36 degrees
S-band - semi-directive links 2025 - 2300 MHz	Receiver system noise figure RF power Antenna gain Bandwidth Cone coverage	6 db 30 watts 0 db 15 MHz 120 degrees
VHF-band links 126 to 144 MHz	Receiver system noise figure RF power Antenna gain Bandwidth Spherical coverage	6 db 25 watts 0 db 2 MHz

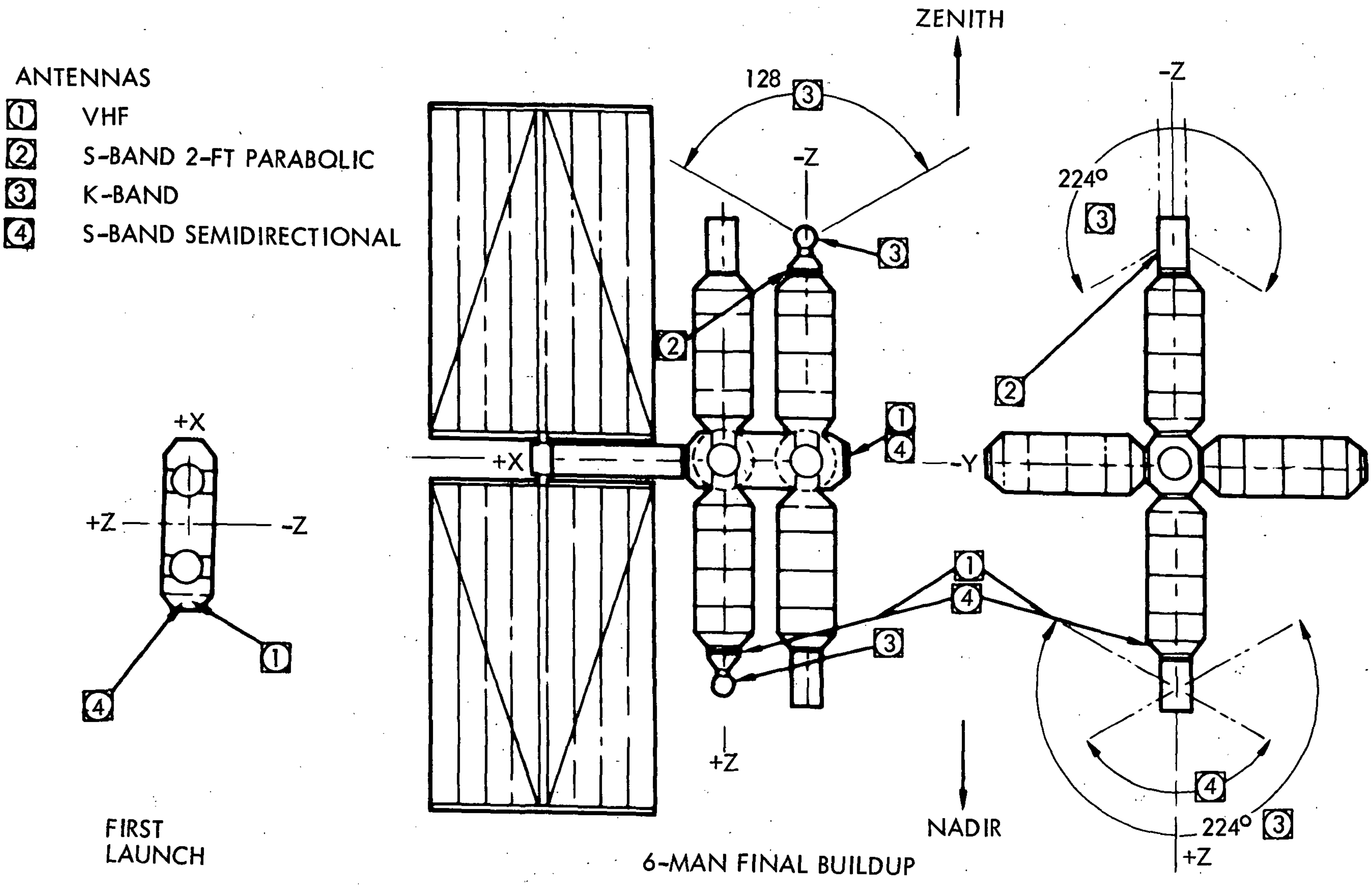


Figure 2.1-29. Antenna Location Selected Configuration

2.1.5.4 Internal Communications

The functional block diagram in Figure 2.1-30 illustrates the interconnection scheme of the major hardware items in the MSS internal communications subsystem. It is organized into a communications rack, recording units, audio-visual units, TV monitors, and hardwire intercommunications subsystems.

The communications rack will process audio, video, and digital data in preparation for downlink RF transmission and will perform the equivalent process for uplinked transmissions. This rack also includes facsimile transmitters and printer units. One communications rack will be installed in each of the control modules (SM-1 and SM-4).

The recording unit will include capability for recording video, audio, and digital data. The equipment list consists of video recorder, audio recorder, entertainment records, and cartridge digital records. There will be two units installed, one in each of the control modules.

The audio-video units provide the man interface at the terminal points for private phones, paging, entertainment music, and video input/output. This unit is a self-contained unit consisting of a push-button telephone unit capable of transmitting both voice and digital data. One of these units is located in each of the habitable areas.

TV monitors will be used in the MSS for CCTV monitoring of experiment activity and entertainment programming. The units are a commercial color TV-type capable of receiving six channels. No direct RF reception capability is provided. TV cameras also will be provided for experiment operations, docking activities, and special area monitoring. These cameras also will be of commercial quality color and black and white units and will be located in the control centers and the GPL.

In addition to the telephone and video bus system previously discussed, there will be a backup hardwire intercommunications system provided. It will consist of sound-powered phones located in each of the modules.

The major performance characteristics of the hardware previously described are listed in Table 2.1-4.

2.1.5.5 Software

Computer programs, microfilm printer paper, and facsimile paper used on board the MSS are classified as software.

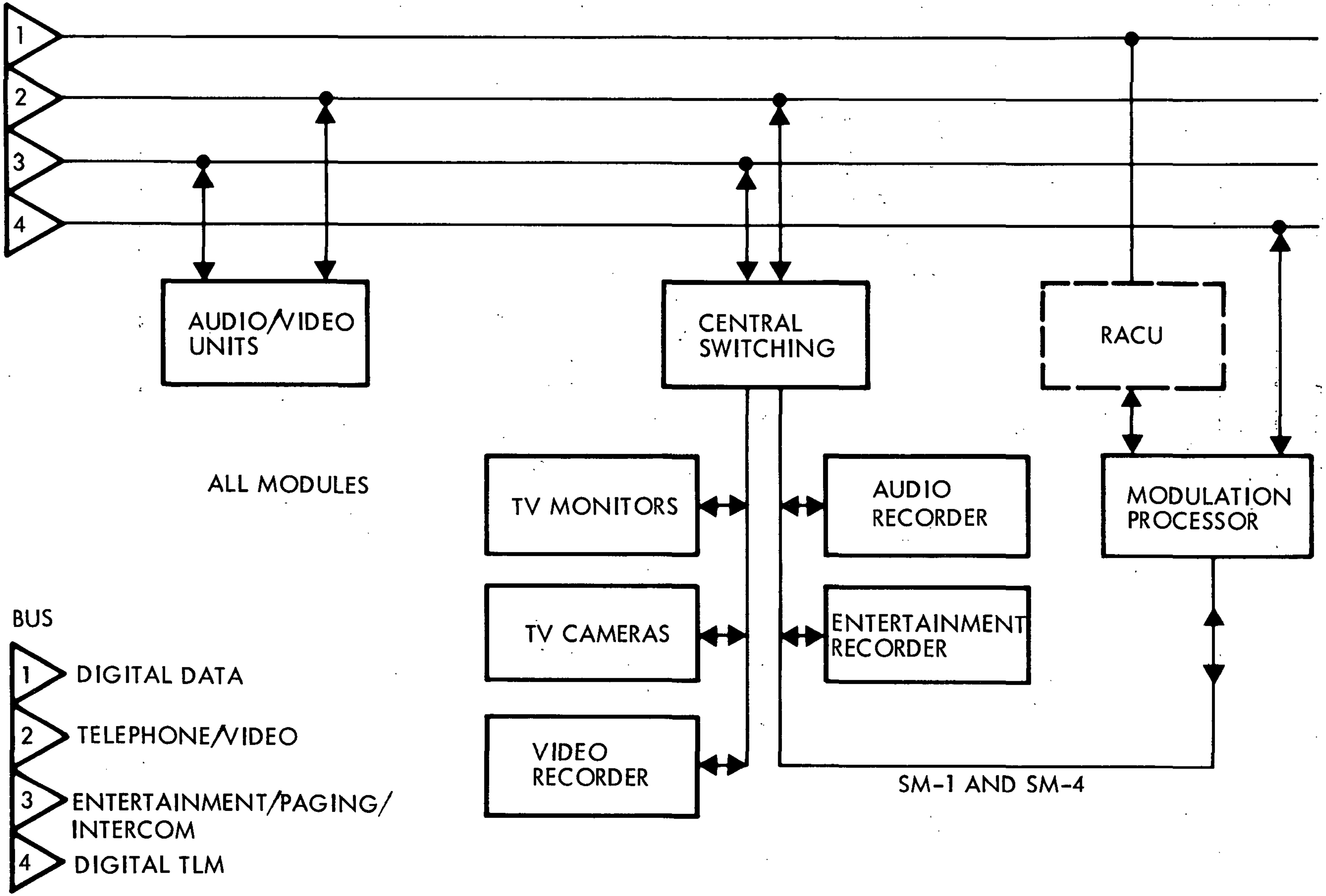


Figure 2.1-30. Internal Communications

Table 2.1-4. Internal Communication Performance Characteristics

Unit	Characteristic	Performance
Communications rack	300-to 3-KHz base band 30- to 10-KHz base band 4.5-MHz base band TV channels 2.9-MHz base band TV channels No degradation in quality Paging power Transmission resolution	12 channels 1 channel 6 30 watts 10 lines/mm Halftone (picture)
Recording unit	4.5-MHz bandwidth 300- to 3-KHz bandwidth 30- to 10-KHz bandwidth 2×10^6 bps 0.5×10^6 bps	2 channels 2 channels 2 channels 2 channels 2 channels
Audio-visual units (AVU's)	Private phone - 300- to 3-KHz bandwidth, digital phone identification Paging - 300- to 3-KHz bandwidth, which overrides all other communication Entertainment music - 30 to 10 KHz bandwidth with volume control One channel video input (selected in camera) One video output channel (selected in monitor)	
TV cameras	525 lines resolution Commercial color Commercial black and white	
TV monitors	Commercial TV quality color 6 channels	
Hardwire intercomm	1 channel	

Computer programs required by the DPA to support subsystems in the performance of their function are dubbed on tape cartridges and stored in cabinets in the control centers.

Microfilm in the MSS is used for storage of information in text, pictorial, graph, and drawing formats. These data sources will be used to support checkout maintenance, MSS operation, and crew entertainment on board the MSS. Microfilm will be packaged in 16-mm cartridges (6000 frames per cartridge) and will be stored in cabinets located in the control center.

Printer paper for the hard text printers in the station will be stored in cabinets located in the control centers.

2.1.6 STRUCTURAL AND MECHANICAL SUBSYSTEM

The structural and mechanical subsystem is comprised of the primary and secondary structure, environmental shield, berthing, and general purpose lab furnishings as depicted in Figure 2.1-31. The space station structures subsystem provides the living and working quarters for the crew in orbit and contains the quarters' atmosphere. The structures subsystem contains mounting provisions and serves as a shelter for other space station subsystems and functional program elements. It also provides a shelter for the storage of consumables, support for the berthing ports, and mechanisms for crew and equipment transfer. The structure must withstand, without failure or excessive deflection, loadings caused by aerodynamic and inertia forces, vibration and acoustics, and compartment internal pressure during prelaunch, launch, boost, and orbital operating conditions. The structure also must provide adequate stiffness to the assembled launch or orbital vehicle configurations for satisfactory control characteristics. The structure must have a useful orbit life of 10 years without replacement or extensive reconditioning of the primary structure.

2.1.6.1 Primary Structure

The primary structure is designed to conform to an envelope defined by a cylinder 15 feet in diameter and 58 feet in length. The structure is designed for a useful life of 10 years without replacement or extensive reconditioning. Primary structure is defined as that structure common to all basic structural elements, including sidewalls, bulkheads, trunnions, and airlock bulkheads. Figure 2.1-32 illustrates the universal module primary structure arrangement.

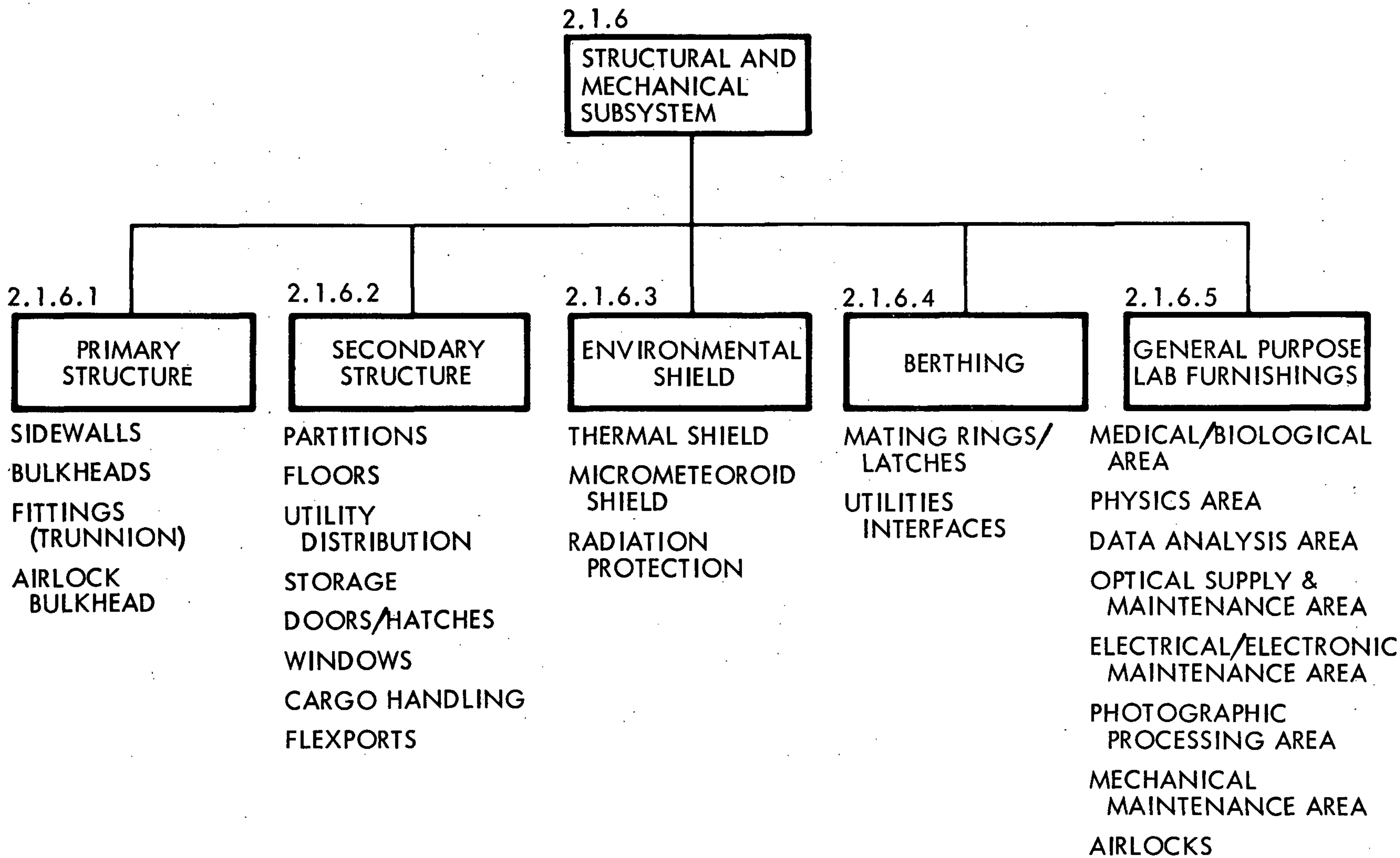


Figure 2.1-31. Structural and Mechanical Subsystem

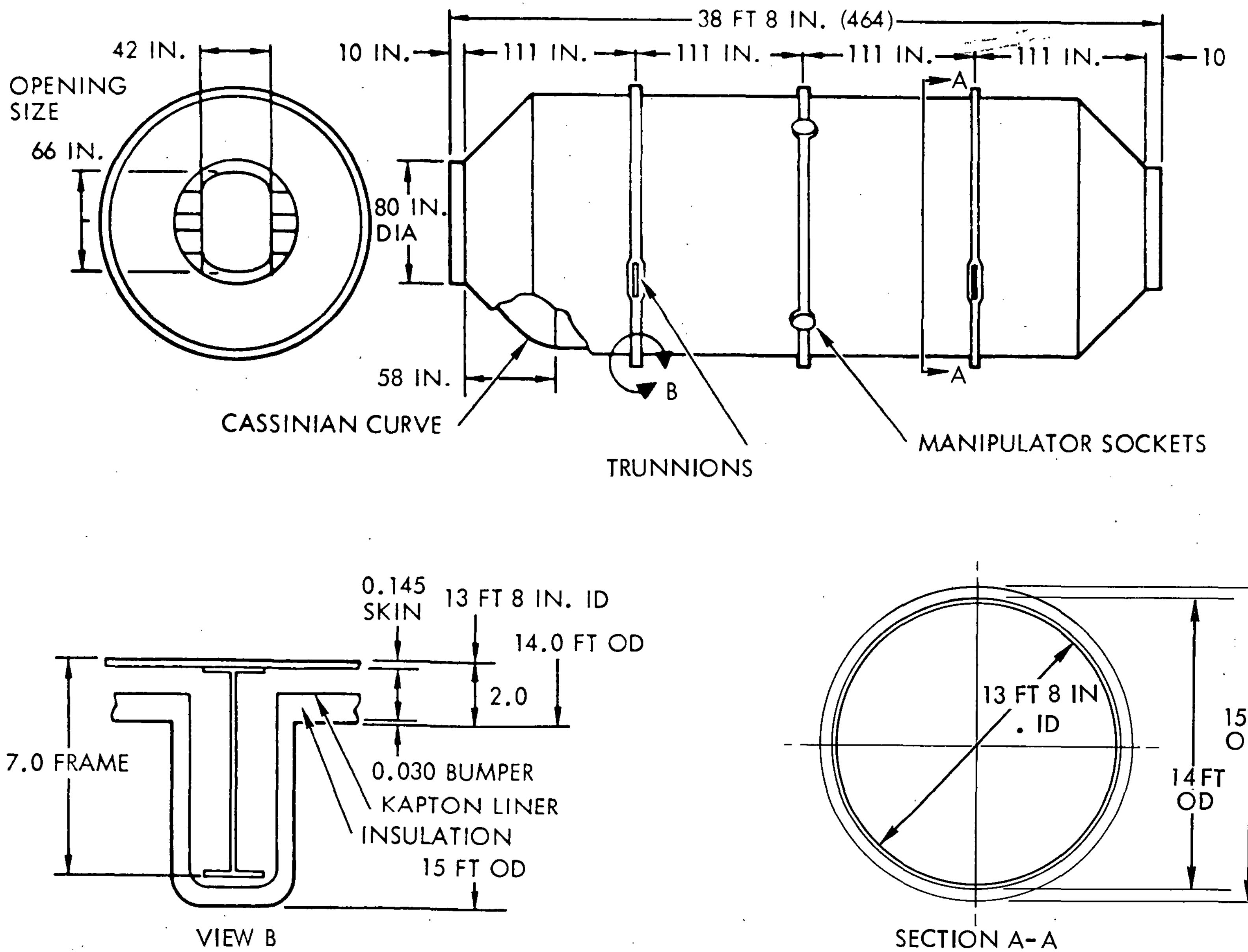


Figure 2.1-32. Command Module Structural Arrangement

The common module structure has three external hoop frames with four manipulator fittings and four trunnion fittings for tie-down in the cargo bay. Berthing ports are located on each end of the module. One active port and one passive port are on each common module.

The core module has a unique primary structure, in that it has multiple berthing ports on the side walls of the cylinders. Stiffening ring frames around the berthing ports are required to obtain the necessary stiffness to ensure that the natural frequency of the structure remains below 1 hertz. There are six stiffening ring frames on the core module as compared to three on common modules.

2.1.6.2 Secondary Structure

Floors, partitions, equipment mounting, and other structure peculiar to a particular configuration are considered secondary structure.

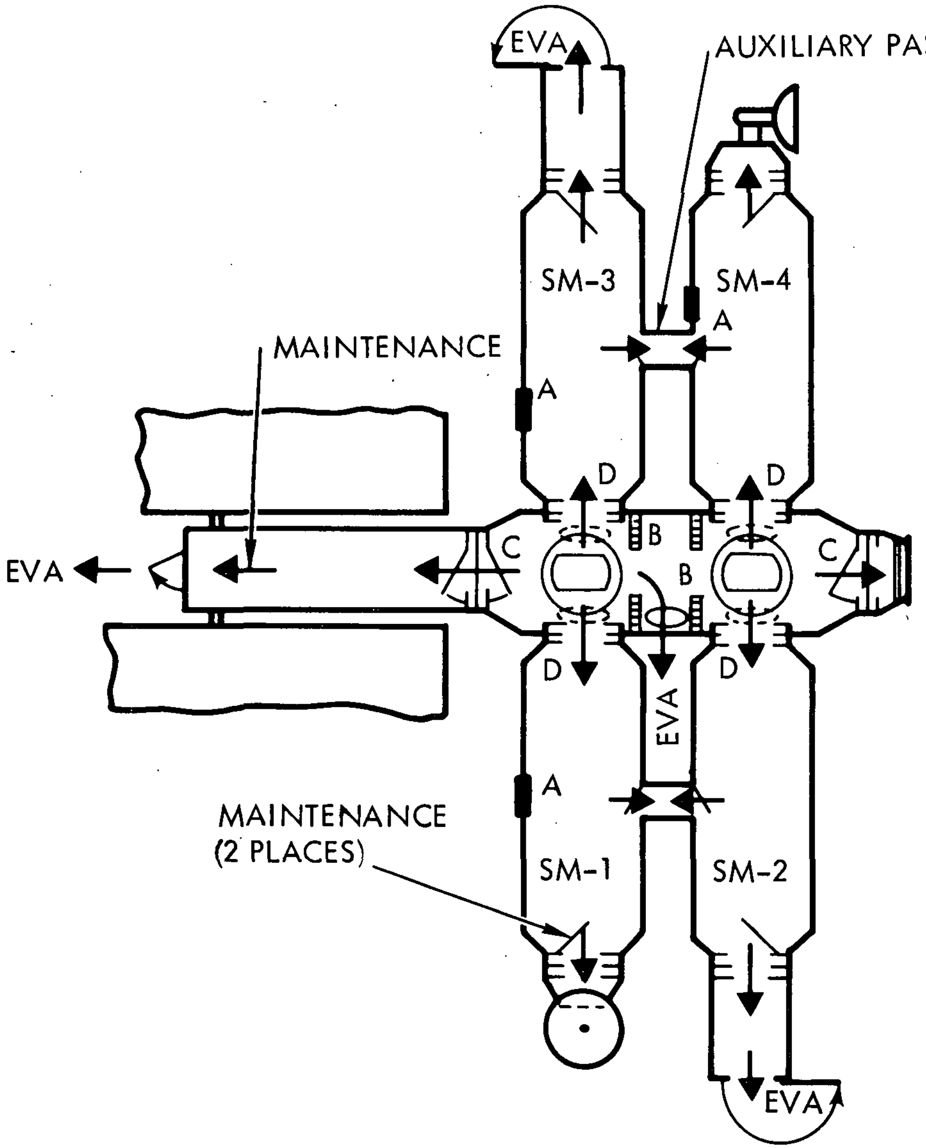
Window and hatch locations are illustrated in Figure 2.1-33. SM-1 will have one window on the minus (-) Y side of the control center, and SM-4 will have one window on the plus (+) Y side of its control center. These windows enable the crew to confirm attitude by external reference. One window will be located on the minus (-) Y side of the dining area of SM-3. There are no windows in SM-2.

Flexports are provided on SM-2 and SM-4 with receptacle rings and hatches on SM-1 and SM-3 for interconnection of the modules.

Equipment and material movement capability will be provided as part of the secondary structures. This will include tracks, guides or other constraining devices, and spacing and friction controls.

Floors in the core module will be transverse and will be longitudinal in the station modules. Primary access routes will accommodate packages 40 by 40 by 50 inches, and secondary routes will accommodate packages 22 by 22 by 50 inches. Primary access routes includes berthing interfaces, halls, aisles, and doors within compartments that contain primary subsystem and major mission-oriented equipment. Secondary access routes are those that are parallel to or in addition to primary routes such as access for example to the crew quarters, galley, and film developing laboratory.

The ceiling height in general mobility areas on the main deck of the modules will be at least 82 inches.



A - SM WINDOWS
- CONTROL CENTERS
- DINING & RECREATION

B - PRESSURE BULKHEAD

C - THERMAL COVERS ONLY
- 4 Y-AXIS PORTS

D - BERTHING PORT HATCHES
- RETURN STATION MODULE HATCHES TO EARTH
- RETAIN CORE MODULE HATCHES

Figure 2.1-33. Window Locations

Utility distribution includes hazardous fluid or gas lines, which will be double-walled and vented as well as being barriered or physically separated from power wires and each other. Hydrogen and oxygen gas also will be barriered or separated from each other. The utilities distribution also includes redundant electrical distribution runs for primary power and other critical distribution. Conditioned atmosphere ducts will be located in all functional areas for the purpose of satisfying crew comfort requirements.

2.1.6.3 Environmental Shield

Station protection from micrometeoroid impact and subsequent penetration is provided by the environmental shield. The structure also will provide shielding to minimize the radiation exposure and dosage of the crew in addition to providing the thermal shield.

2.1.6.4 Berthing

The berthing port hatches will provide a nominal opening of 5 feet and accommodate the passage of crewmen dressed in pressure suits and also allow the passage of packages of 40 by 40 by 50 inches.

Berthing ports provide the utilities interfaces within the pressurized volumes. Berthing ports will be located on both the plus (+) X and minus (-) X-axis of each module. The core module will have additional ports on the side wall area.

Figure 2.1-34 illustrates the module to module berthing, and Figure 2.1-35 illustrates the utilities interface of the berthing ports.

2.1.6.5 General Purpose Laboratory Furnishings

The general purpose laboratory furnishings of the structural and mechanical subsystem consist of various area and equipment allocations within the station that are used for various activities as shown in Figure 2.1-31.

SM-3 contains the area for physics experiments. This includes a portable reflectometer, a sample and retrieval box, a mass spectrometer, and a work bench. In addition to the physics area, space and equipment for medical and biological work are provided. Equipment for medical and biological includes a total carbon analyzer, a nitrogen analyzer, a calorimeter, a culture chamber, a lyophilizer, and two incubators.

SM-2 will provide space for mechanical maintenance, electrical and electronic maintenance, optical supply and maintenance, and airlock loading access.

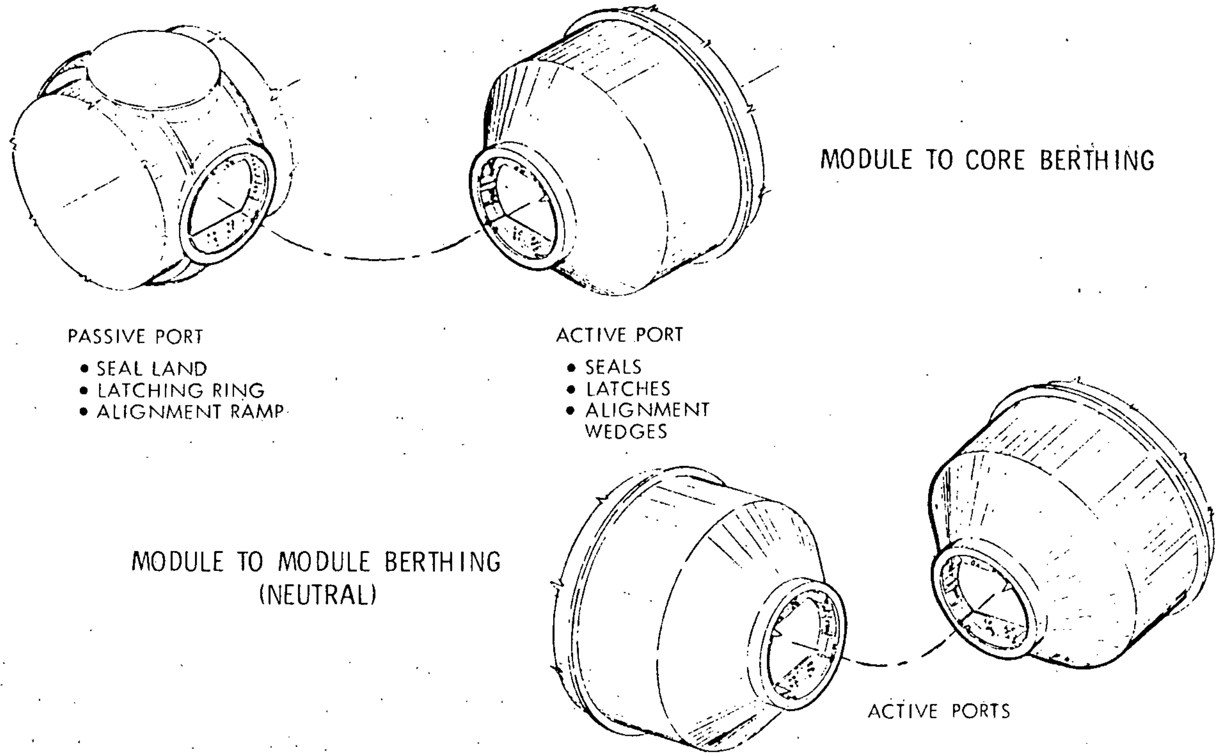


Figure 2.1-34. Berthing

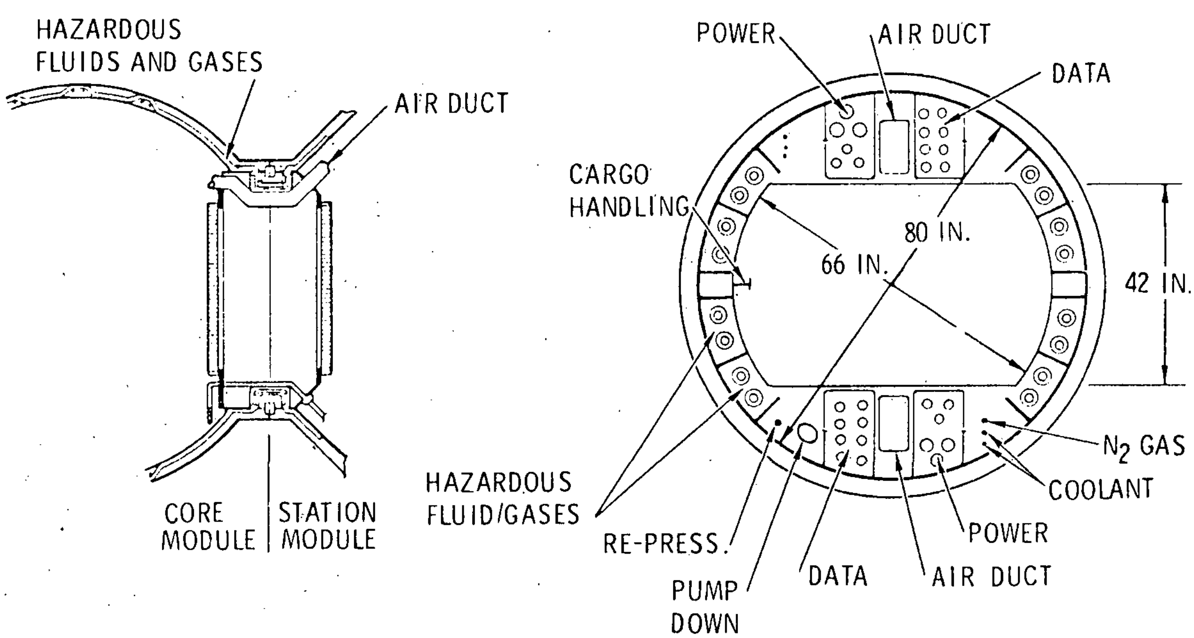


Figure 2.1-35. Berthing Interface

Experiment airlocks are located on SM-2 and SM-3 such that one is on the nadir and the other on the zenith as shown in Figure 2.1-33. Figure 2.1-36 illustrates the experiment airlock. An active berthing port is on the module end of the airlock. The other end has an experiment hatch that can be opened to allow the deployment of experiments on a platform attached to rails. The experiment hatch contains a window. The airlock has insulation applied completely around it.

The data analysis area will contain a control console, work bench or desk, light table, film viewer, X-Y plotter, and tape deck. In conjunction with the data analysis area, a photo processing area will contain a work bench, light table and storage cabinet, in addition to the photographic equipment.

2.1.7 CREW/HABITABILITY SUBSYSTEM

The crew and habitability subsystem consists of the crewman, their personal effects and equipment, and EVA/IVA pressure garments and support equipment. Also included are food supplies, furnishings, crew and equipment restraint devices, tools, mobility aids, recreation, exercise and medical equipment, and cargo handling equipment.

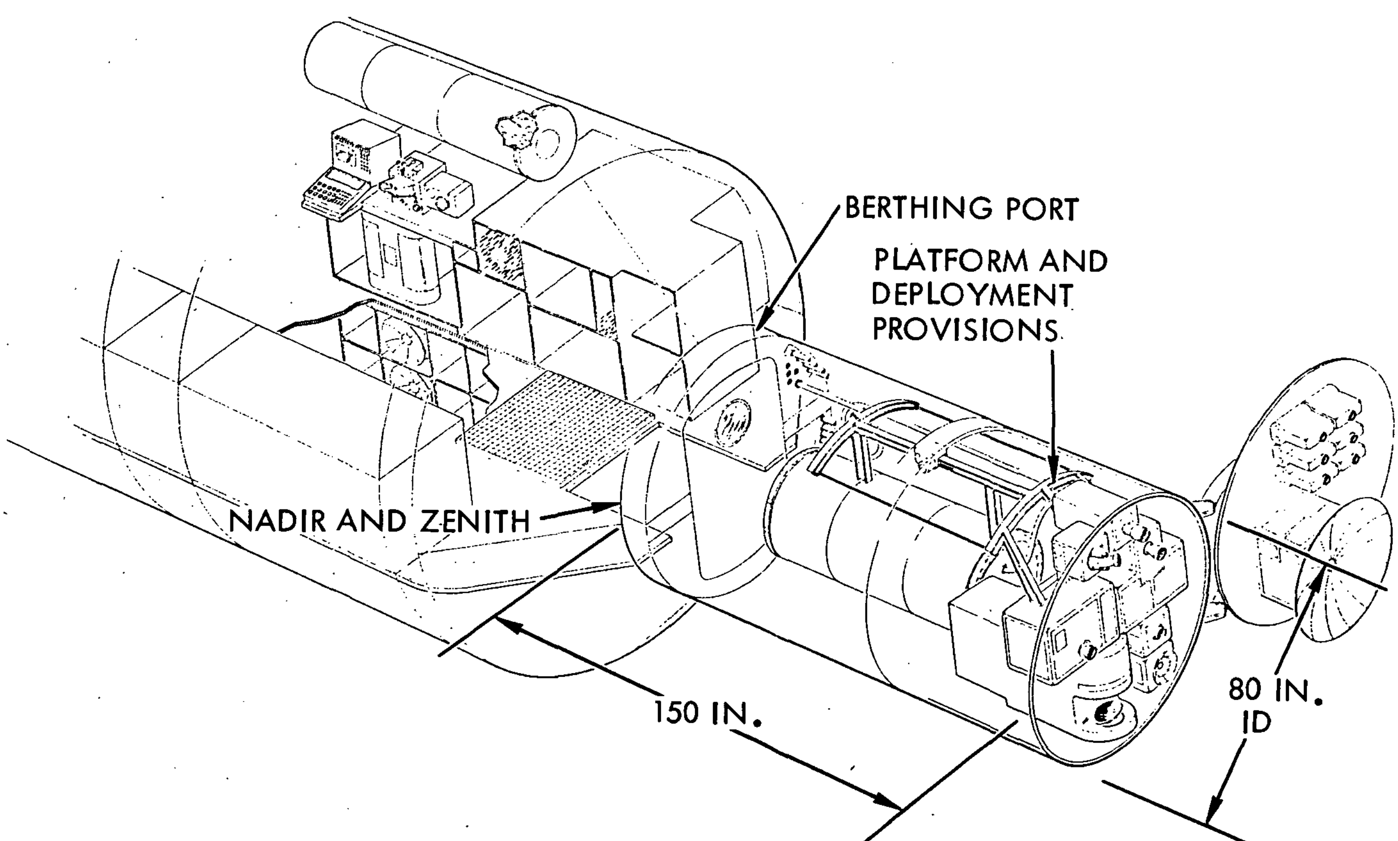


Figure 2.1-36. Experiment Airlock

Figure 2.1-37 shows the elements of the crew and habitability subsystem.

2.1.7.1 Personal Equipment

The crew personal equipment items include wearing apparel, linens, grooming aids, and personal equipment. The crew personnel equipment items provide for the comfort and individuality of each member of the crew and safety considerations with personal radiation dosimeters.

There will be no laundering capability on the MSS; hence, all clothing will be disposable.

2.1.7.2 General and Emergency Equipment

The general crew equipment items provide for crew locomotion, stabilization, work capability, and safety during the mission. Mobility aids facilitate crew movement and interdeck transit and also provides for crew stabilization. Crew restraint devices provide for crew bracing and stabilization as well as the prevention of inadvertant drift in the zero-g environment and the ability to maintain a crewman in a relatively fixed position. Equipment restraint devices are provided for the retention of loose equipment items. Cargo handling and transport devices provide for transfer of cargo and equipment from the shuttle or cargo module as well as within the station itself.

Emergency equipment will include portable oxygen tanks and breathing face masks located in each module in sets of three per module. These units will provide a sufficient breathing duration to allow the personnel faced with the emergency to evacuate that area or perform other emergency functions with a mask.

Two liquid-cooled garments (LCG), two pressure garment assemblies (PGA), and two portable life support systems (PLSS) are located in each of the two pressure volumes. IVA umbilical connections and hoses of sufficient length to reach all of the interior of the volumes will be provided. This will require hoses approximately 55 feet in length (including instrumentation cable) and water and oxygen hoses. First aid kits and portable lights will be strategically located in each volume.

2.1.7.3 Furnishings

The crew furnishings provide the accommodations necessary for the crew living quarters and work areas. Crew quarters will include bunks

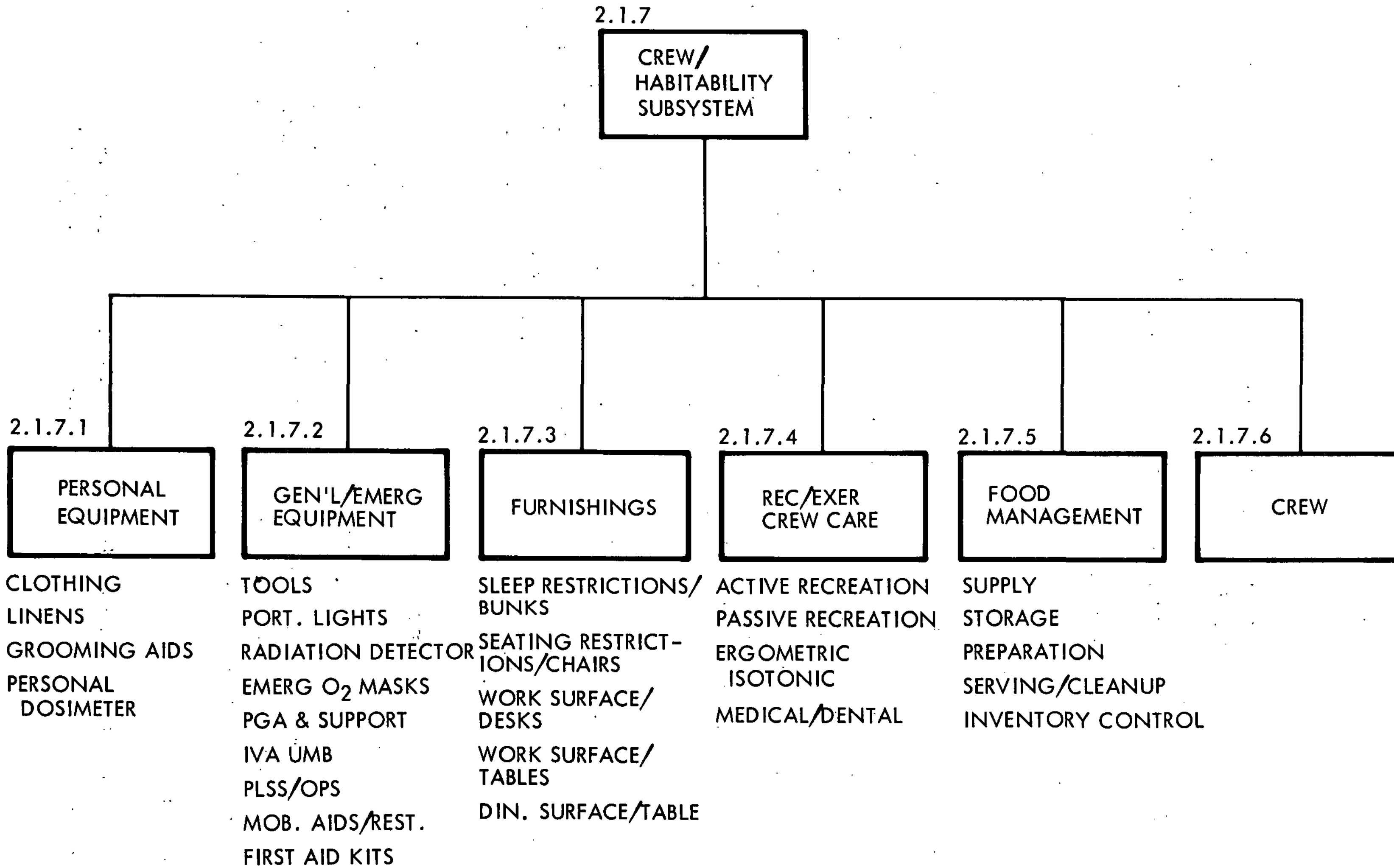


Figure 2.1-37. Crew/Habitability Subsystem

with restraints for sleeping in the zero-g environment. Seats also will have restraints for the zero-g environment. Desks and tables will be provided for work surfaces, and tables will be used for dining surfaces.

2.1.7.4 Recreation/Exercise and Crew Care

Various items are provided for crew recreation, exercise, and medical care. A variety of active and passive recreational devices is provided for both individual and group activities, including such items as games, reading material, music, and television. Exercise equipment includes a bicycle ergometer and isotonic equipment (bungee cord apparatus).

Both diagnostic and medical and dental treatment equipment are provided, in addition to a variety of medicines and drugs, medical and surgical instruments and accessories, and expendable medical supplies.

Seating arrangements and an examination table will be outfitted with restraint devices.

2.1.7.5 Food Management

Equipment necessary to prepare, preserve, and serve the food required for the crew nutritional needs will be provided. All equipment will be convenient and easy to use in the zero-g environment and will be based on a shirt-sleeve mode of operation.

Both frozen and chilled food storage will be provided. Equipment will be available to meter both hot and cold water for reconstitution of dehydrated food. Ovens will be provided to heat prepackaged meals (up to 12 packages simultaneously).

Provisions for washing nondisposable cooking, serving, and eating utensils will be included in the galley. Sinks will serve both the galley and the dining area for crewmen to wash their hands as well as utensils.

A trash disposal/compactor will provide efficient and sanitary disposal of waste foods, liquids, food packaging materials, and other disposable items.

2.1.7.6 Crew

The initial modular space station will provide the capability to support a nominal crew complement of 6, with a maximum capability to support 12 crewmen for a short duration for crew rotational overlap or logistics resupply periods.

All man-machine interfaces are based on a 5th- and 95th-percentile male or female crewman in both shirt-sleeve and spacesuit modes of operation.

The crew will normally consist of a commander, an experiment coordinator, technical operations, and an experiment crewman.

2.2 MSS TEST AND OPERATIONAL REQUIREMENTS

This section defines the test and operational requirements for the initial station launches planned during 1981 and for the growth launches scheduled for 1987. During the interim between these periods, launch activity will be devoted to checkout of resupply missions with cargo modules and, where necessary, repair and modification and checkout of modules returned from orbit. Running parallel with these operations, integration tests will be conducted on experiment modules to be launched, which may be built by another vendor. The requirements will be specified for each module separately and for each uniquely identifiable operation associated with its anticipated flow.

Integration tests for the flight modules (core, power, SM-1, and SM-2) will be completed at the factory. These MSS elements will be operated together in as near possible simulation of free-space conditions prior to shipment to the launch site (KSC). As a result of this comprehensive testing at the factory, tests at the launch site will be oriented more toward functional and systems verification tests for these initial station modules. SM-3, SM-4, and the cargo module will be accepted at the launch site. The mission support vehicle (MSV), discussed later in this report, will play a significant role in the initial station systems verification testing.

Later in the MSS program (1987), a larger solar array (10,000 square feet) will replace the initial station array (7000 square feet), and another core module (short) and two station modules (SM-5 and SM-6) will produce the 12-man growth station.

2.2.1 INITIAL MSS LAUNCHES

The modular space station program is composed of two phases: the initial station buildup to a 6-man operating level and the growth station phase which follows the initial approximately 5 years later. The growth station will accommodate a 12-man operating level.

The initial station configuration chosen is cruciform as shown in Figure 2.2-1. The special modules are the 40-foot core and the 37-foot power modules. Four station modules (designated SM-1 through SM-4) are common modules. Cargo and RAM modules, located on the Y-axis ports, are essentially common modules as well.

The initial station dimensional characteristics are shown in Figure 2.2-2. The complete initial station configuration summary is shown in Figure 2.2-3, which is comprised of two separate volumes with the division occurring at the EVA/IVA airlock of the core module. Figure 2.2-4 indicates the composition of the station modules that form portions of the separate volumes. It may be noticed that, despite deactivation of a given volume, the remaining volume retains the function of crew quarters (double occupancy), control, waste management, air revitalization, medical, and food facilities.

2.2.1.1 Off-Load and Transport to Checkout Site

The off-loading operation and transport to the checkout site begins when the modules arrive at KSC via the air transportation system provided by NASA. The four initial modules will have already completed acceptance tests at the factory. The remaining modules will be acceptance-tested at the launch site. They will arrive in an inert condition (i.e., systems containing pyrotechnics and ordnance, high-pressure gases, toxic fluids and other items potentially hazardous to personnel during handling operations will have been removed or inactivated prior to shipment to the launch site).

Off-loading will necessitate the requirement for a transporter vehicle to move the modules to the checkout site (MSOB) and subsequently to the shuttle orbiter and cargo loading site (VAB). The transporter may need to supply power and cooling to equipment installed in the modules (e.g., the IMU of the CSM for the Apollo program required constant heater supply power for the gyros). Lifting slings or fixtures will be necessary for conducting move operations of the various modules. Standardization of all GSE, including the transporter and handling equipment, will be a design goal to minimize the quantity of such equipment.

The launch operations processing schedule for the initial MSS (Figure 2.2-5) shows the overall activities that each flight module will undergo from the time of its delivery to launch.

The utilization of the flight core, power, SM-1, and SM-2 modules during integrated tests at the factory results in the simultaneous completion of testing of these elements. Figure 2.2-5 indicates the completion in June 1981 with the delivery of the first four modules at that time.

The deliveries of SM-3, SM-4,and the crew/cargo modules occur at the proper time to support the acceptance testing and launch preparation minimal periods.

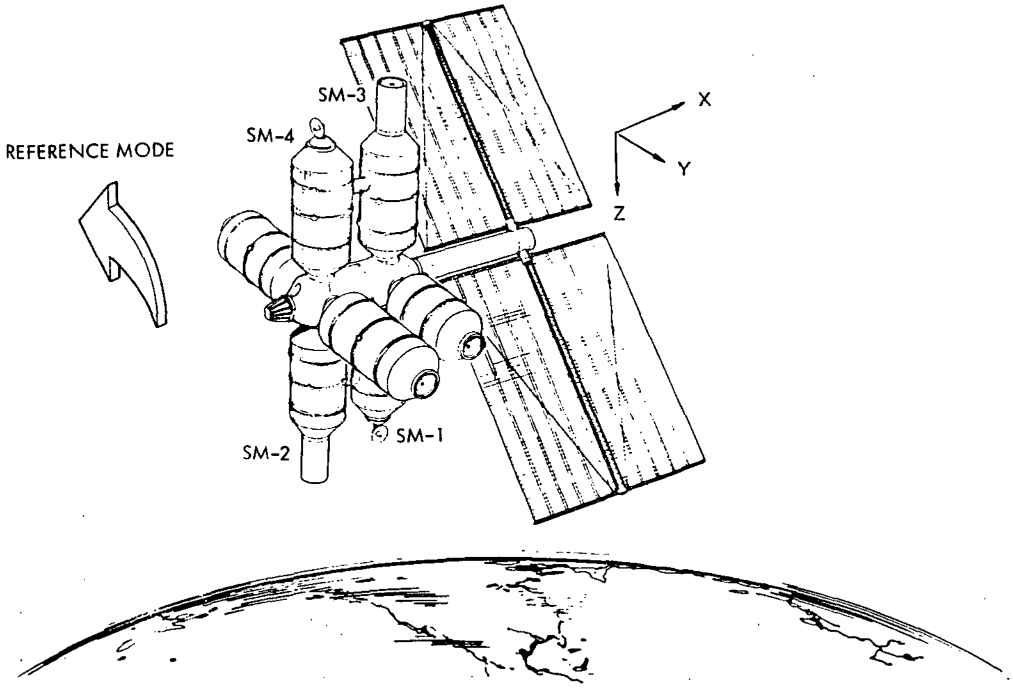


Figure 2.2-1. Selected Configuration Initial Station

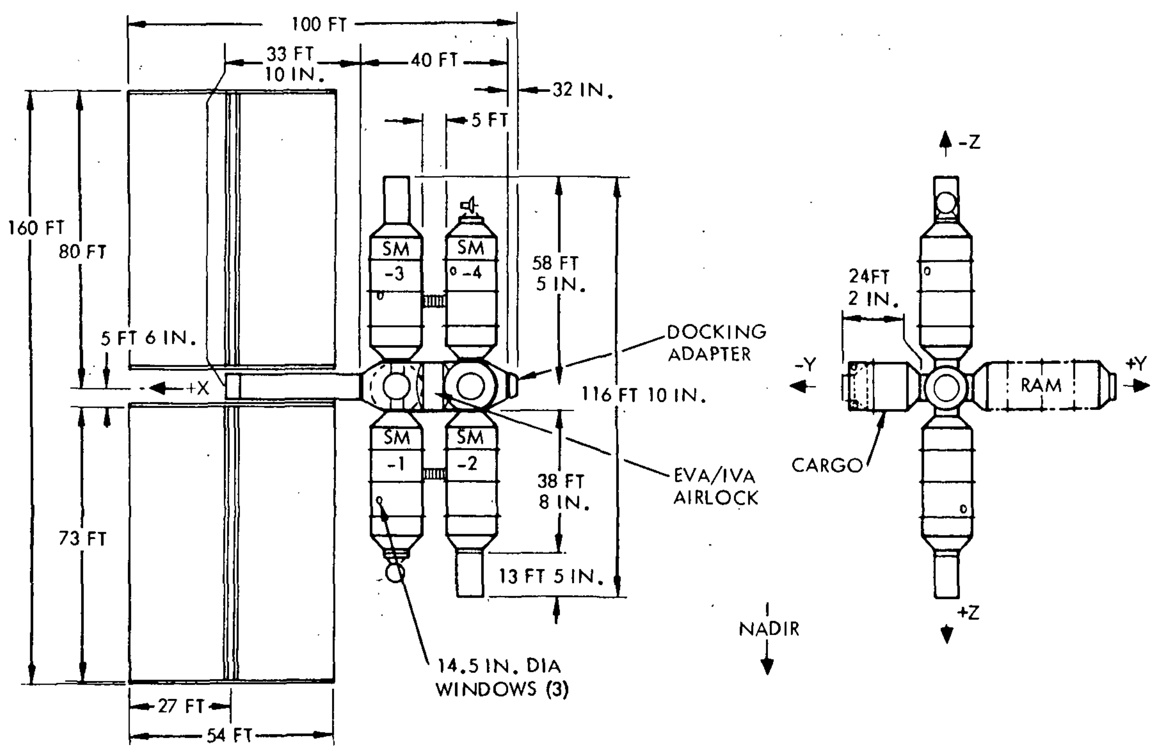


Figure 2.2-2. Initial Station Dimensions

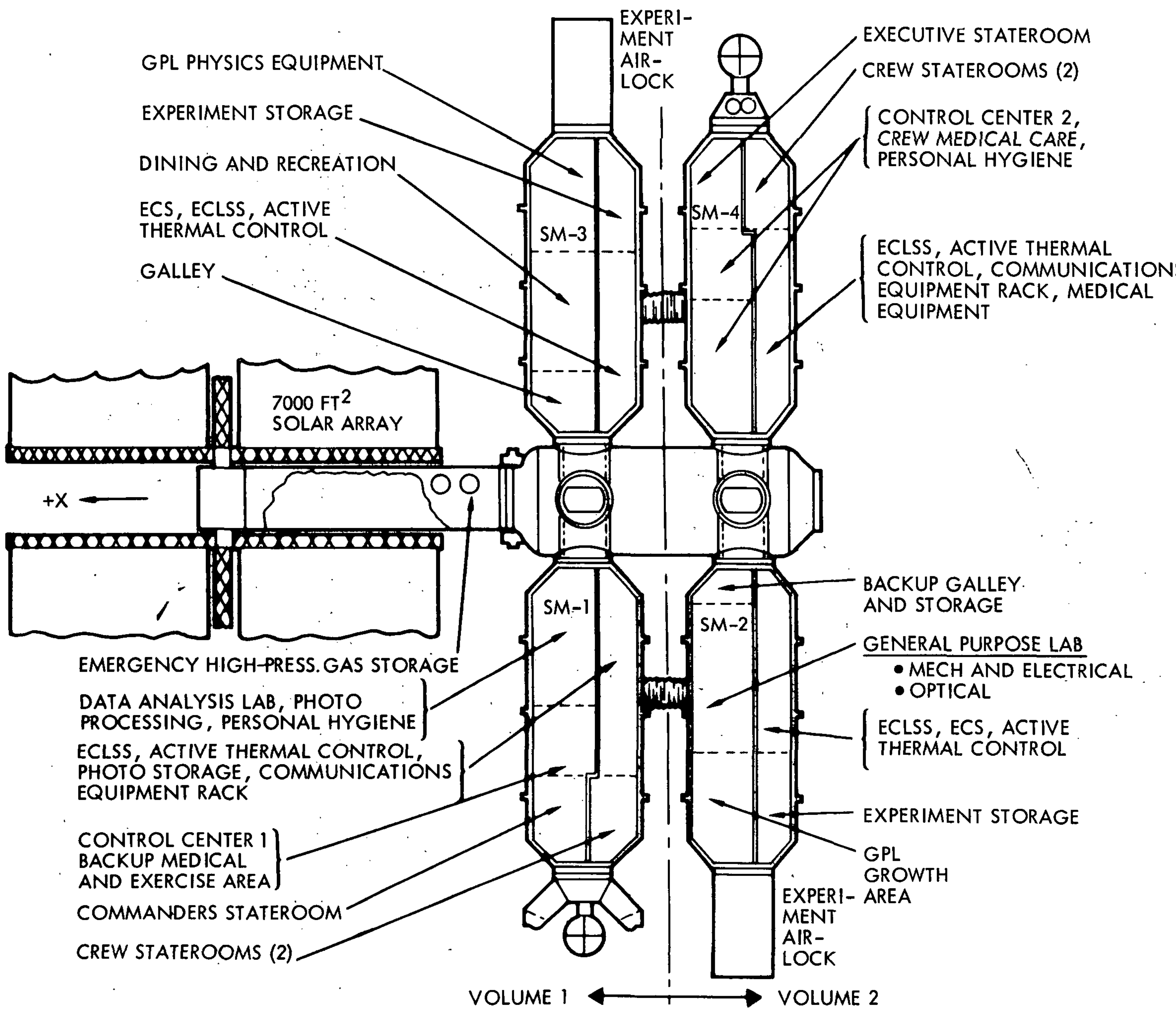


Figure 2.2-3. Initial Station Configuration Summary

VOLUME 1

	CREW/CONTROL (SM-1)	
ABOVE DECK	COMMANDER/EXEC STATEROOM CONTROL CENTER & DATA ANALYSIS BACK-UP MEDICAL PERSONAL HYGIENE	① ④ ⑤
BELOW DECK	CREW STATEROOMS (2) WASTE MANAGEMENT EQUIPMENT STORAGE	

	LAB/DINING/ATMOSPHERE MGMT (SM-3)
ABOVE DECK	PHYSICS BIOMED LAB ZENITH AIRLOCK GALLEY & WARDROOM
BELOW DECK	AIR REVITALIZATION EQUIPMENT STORAGE

VOLUME 2

	LABORATORY/ATMOSPHERE MANAGEMENT (SM-2)
ABOVE DECK	MECHANICAL LAB OPTICAL/ELECTRICAL LAB BIOSCIENCE/EARTH OBSERV LAB NADIR AIRLOCK BACK-UP GALLEY
BELOW DECK	AIR REVITALIZATION EQUIPMENT STORAGE

	CREW/CONTROL (SM-4)	
ABOVE DECK	COMMANDER/EXEC STATEROOM CONTROL CENTER MEDICAL & CREW CARE PERSONAL HYGIENE	① ④ ⑤
BELOW DECK	CREW STATEROOMS (2) WASTE MANAGEMENT EQUIPMENT STORAGE	

Figure 2.2-4. Selected Allocations Initial Station

For the modules that undergo temporary storage periods prior to launch tests (i.e., the power, SM-1 and SM-2, and shipping covers will not be removed until just prior to the checkout operations).

The handling operations for the modules will require an overhead crane. The present 27-ton units (two low bay and one high bay) should be able to handle the expected maximum loading of 25,000 pounds for any given module.

2.2.1.2 Receiving/Inspection and Preparations for Checkout Tests

The core module will undergo receiving inspection tests upon arrival at the MSOB. Shipping covers will be removed and inspection covers and doors removed to perform the necessary inspections to ensure no shipment damage. Internal inspections will be deferred until after clean room access provisions have been made. Berthing and docking interfaces will be particularly scrutinized prior to checkout operations with the UTE.

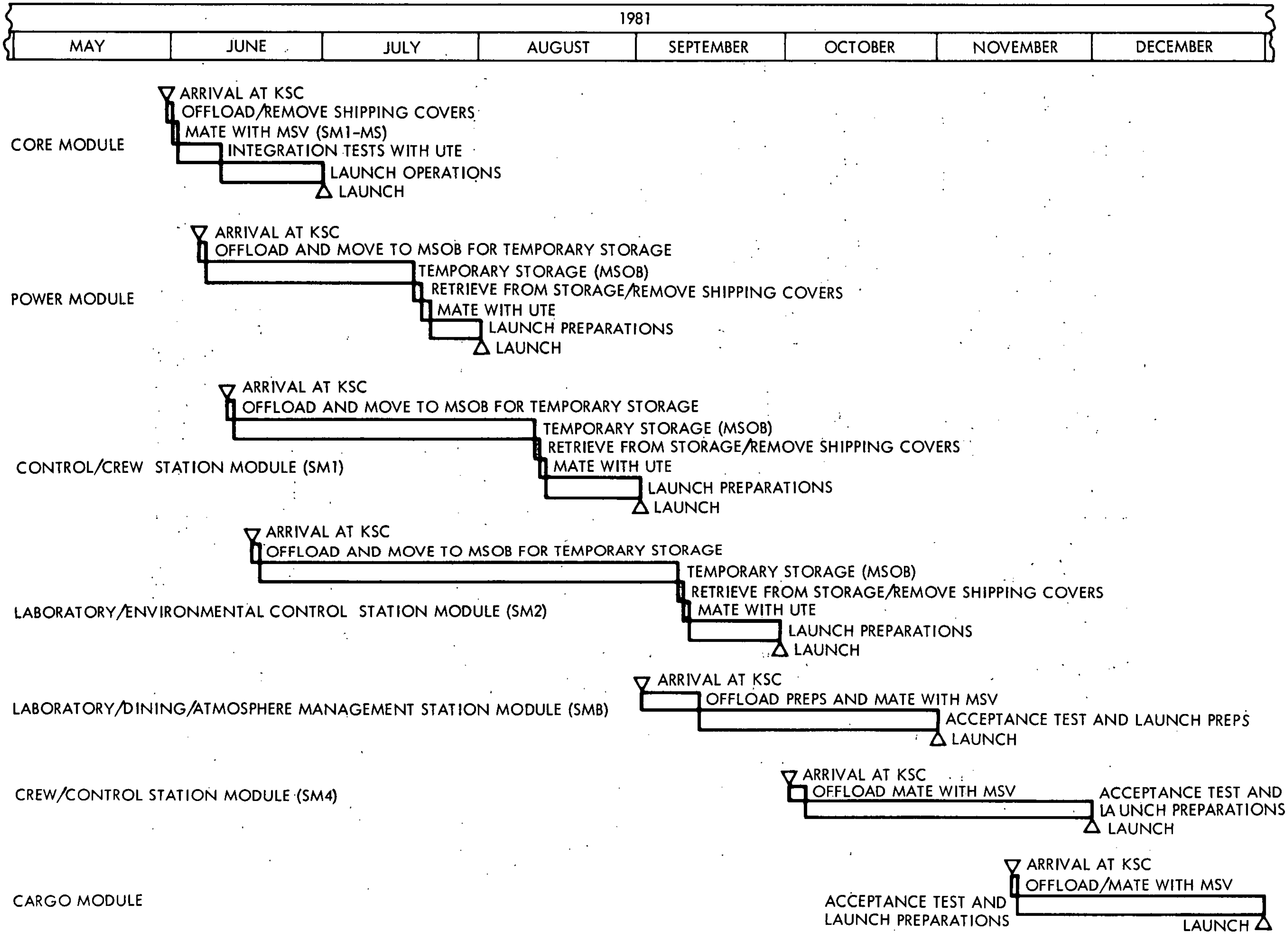


Figure 2.2-5. Launch Operations Processing Schedule

The previously mentioned activities will apply to the power module, SM-1, and SM-2, with the exception that such activities will follow the temporary storage periods for these modules. The solar array of the power module will not be deployed for tests nor for receiving inspection; solar array panel certification will be the responsibility of the vendor.

The remaining modules, SM-3, SM-4, and the crew and cargo will follow the same receiving inspection routine defined for the core module.

The preparation for checkout tests will be mainly concerned with verification of the mating interfaces of the modules. Mating surfaces will be inspected for cracks and abrasions, cleaned, and alodined. Utility interfaces, including electrical connections, quick-disconnects, ducts, etc., will be inspected to ensure proper fit of berthing and docking interfaces.

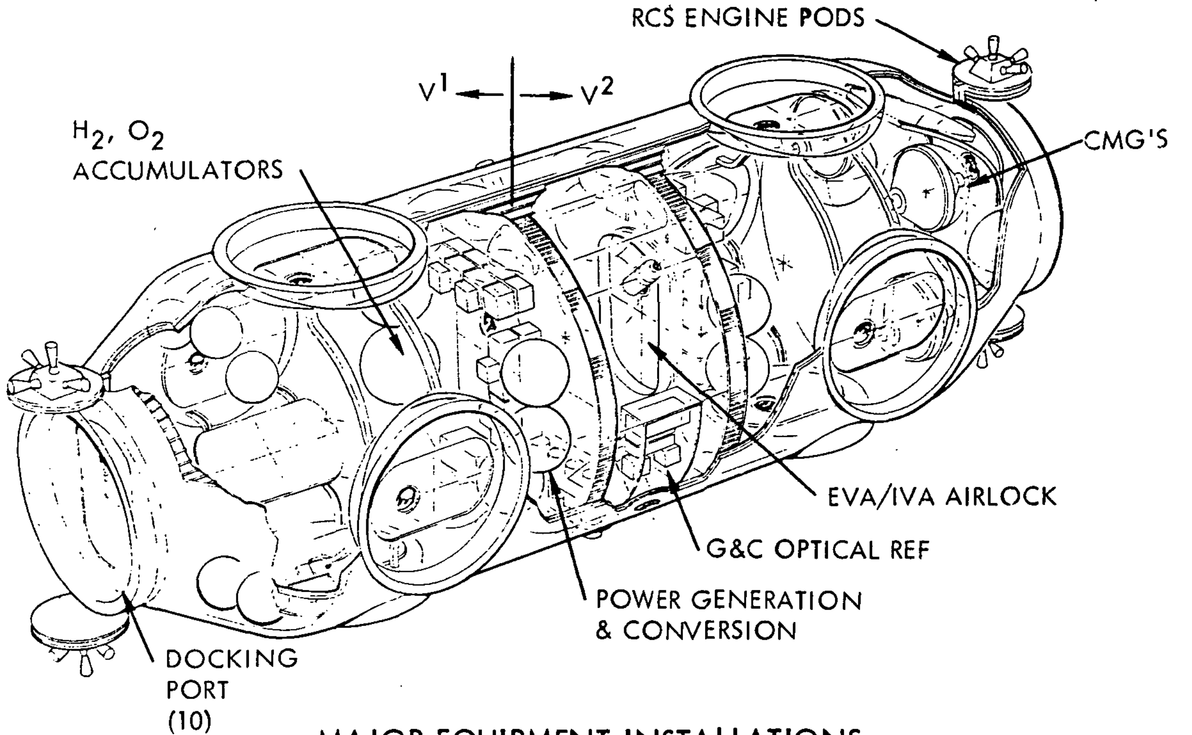
2.2.1.3 System Verification Test Descriptions

Core Module

Configuration. The core module, as the name implies, is the hub of the modular space station. It is comprised of two separate volumes with an intervening EVA/IVA airlock. The portion of the core module forward of the airlock (+X end) is part of volume 1, while the portion aft of the airlock (-X end) is part of volume 2. The two-volume requirement stems from safety considerations in the event of an unscheduled, rapid depressurization of either volume. The major equipment items contained in each volume is shown in Figure 2.2-6. The core module contains the guidance and control (G&C) functions, the reaction control system (RCS), and the bulk of the power generation and conversion equipment. Fuel cells, inverters, and electrolysis units are located on the airlock bulkheads in each compartment. Low-pressure accumulators (300-psi) for the EPS and RCS are installed in the core module. Installation of the G&C, star/horizon trackers and gyros is provided, and the control moment gyros (CMG) are positioned near the research applications module (RAM) docking port. Because of the vital role the core module plays in controlling and stabilizing the MSS via the RCS and G&C system, it is the first station element to be launched.

Systems Tests. The checkout and systems verification tests for the core module will be accomplished on the ECLSS, ISS, RCS, EPS, G&C, crew habitability, and structural/mechanical subsystems. Table 2.2-1 is a summary of the tests to be performed on the core module. A brief description of the tests to be performed per system is provided below:

1. ECLSS. The thermal control loop, atmospheric control, water management, and special life support subsystems will be subjected to verification tests utilizing the UTE.



MAJOR EQUIPMENT INSTALLATIONS

VOLUME 1
EMERGENCY G&C
PORTABLE CONTROL UNIT
S-BAND ANTENNA/XPONDER (3)
VHF ANTENNA/XPONDER (2)
TV CAMERA - BLACK AND WHITE
TV MONITOR COLOR
FEED CONTROL
ENGINE CLUSTER (2)
PRESSURE CONTROL
WATER PUMP PACKAGE
FREON/WATER INTERCOOLER
FREON PUMP PACKAGE
FREON RESERVOIR
FUEL CELL (2)
ELECTROLYSIS UNIT (2)
WATER STORAGE AND PUMP
INVERTERS (4)
REGULATORS (4)
GAS MONITORING
AUDIO/VIDEO UNIT (2)
FIRE CONTROL UNIT (1)
O_2 ACCUMULATOR (1)
H_2 ACCUMULATORS (2)

VOLUME 2
RAM HEAT EXCH (2)
STRAPDOWN IMU
HOR TRACKER OPTICS (4)
SEXTANT/TELESCOPE
STAR TRACKER OPTICS (4)
NAVIGATION BASE
ALIGNMENT LINKS (2)
CMG'S (4)
FUEL CELL (2)
ELECTROLYSIS UNIT (2)

VOLUMES 1 AND 2
FIRE DETECTOR
LOCAL MONITOR ALARM
TV CAMERA COLOR
FIRST AID KIT

Figure 2.2-6. Core Module

The thermal control system will be delivered to the launch site in a cleaned and dry condition. The external loop will require servicing with freon and the internal loop with contaminate-free (deionized) water. If the system design is such that a low probability exists for system leaks during transit, the requirement for delivery in the dry condition may be waivered, thus obviating the necessity for thermal-loop servicing. Thermal-loop functional performance checks with the UTE would remain as a requirement as shown in Table 2.2-1.

Atmospheric control tests of the ECLSS are concerned with the functional performance of the gas monitoring and pressure control subsystems. In addition, leak checks of both volumes of the core module and the airlock will be required. The high-pressure O_2 and N_2 tanks are installed in the power module, which is not available at this time. If the power module were available, its tanks would not be pressurized to their design capacity (3000 psia) because of the building design overpressure limitations of the MSOB in the event of accidental rupture of the tanks. For this reason, pressurization of the core module will require facility supplies of N_2 and O_2, probably connected to a GSE adapter at the core module I/F with the power module. Tests of the atmospheric control system are primarily devised to ensure that the control system is supplying the proper mix and quantity of atmospheric constituents at the proper pressure to assure life support and to verify that the leak rate of the core module is within design tolerances.

Water management system operations will be devoted mainly to potable water servicing of the water storage and pump units. The servicing will be conducted as shown in Table 2.2-1. It is assumed that the potable water purity requirements will be similar to and as stringent as those for the Apollo program CSM. The CSM potable water system was subjected to chlorine "shock" treatments to kill residual bacteria then serviced with deionized, chlorinated water using the S14-119 water servicing unit GSE just prior to launch.

The final test of the ECLSS will be of the special life support system fire control unit and detectors. These will be cursory checks of these items to verify functional operation and will be performed utilizing the UTE.

2. ISS. The command and control and monitoring and communications subsystems verification tests will be accomplished utilizing the UTE.

   The command and control and monitoring subsystem tests will include the portable control unit and local monitor and alarm. The purpose of these tests will be to verify the functional performance of this equipment, including portable fault-isolation and maintenance displays and controls.

   The communications tests will be confined mostly to functional performance tests of the TV cameras and monitors and the audio-video unit. It is assumed the S-band/VHF transponder performance will have been verified at the factory, and that no additional testing will be required at the launch site. Table 2.2-1 shows the ISS tests planned for the core module.

3. RCS. The propellant feed controls, accumulators, and engines will be subjected to systems verification tests with the UTE.

   The propellant feed controls, including valves, regulators, plumbing, etc., will be functionally tested to ensure no leakage. Regulator flow and lockup checks will be part of these tests.

   The propellant accumulators (O_2 and H_2) will be verified to have no leaks at the time the feed control tests are made.

   Engine tests will be accomplished for all four quads (four engines each). Injector valve leakage and valve signature (response) will be the primary considerations. RCS and G&C polarity checks will be conducted with portions of the guidance and control (G&C) system powered up to verify G&C inputs produce the proper engine response. The RCS tests for the core module are shown in Table 2.2-1.

4. EPS. The EPS verification tests will include functional operation of the fuel cells, electrolysis units, inverters, power regulators, and lighting with the core module mated to the MSV. To operate the fuel cells and electrolysis units, a source of GO_2, GH_2, and GN_2 will be required and will be assumed to be facility-supplied. Fuel-cell flow checks will be accomplished using the facility gases previously mentioned. Loading of the fuel cells for current-voltage determinations can be performed using load banks. Water production from the fuel cells and electrolysis unit O_2 and H_2 production rates can be evaluated against the electrical loads. Fuel cell heat-up and cool-down allowances were included in the fuel-cell test flow plans.

Table 2.2-1. Core Module

System	Test and Operational Requirement	Purpose and Rationale	Test and Operational Technique	Support Requirement UTE/MSV	Support Requirement GSE
ECLSS					
Thermal control loop					
RAM heat exchanger Water pump package Freon/water intercooler Freon pump package Freon reservoir	Freon/water servicing and leak check. Functionally check system performance.	Provide coolant to the thermal control loop. Shipment from factory requires dry system. Verify that system performance has not been degraded resulting from shipment and that system is ready for launch.	Verify the thermal control loop is clean and dry before evacuating for servicing. The system shall be considered dry when a dewpoint reading of -65 F is attained. This is accomplished by purging with air or nitrogen at 200 F until the dewpoint reading is attained. GN_2 source pressure shall be established by design specifications. A vacuum source will be required for the filling operation. When vacuum pressure is stabilized, a decay pressure check will be made. Operate system.		Freon servicing equipment; water servicing equipment; leak detector unit; vacuum pump.
Atmospheric control					
Gas monitoring Pressure control	Verify functional performance of the atmospheric pressure control and trace gas monitoring systems. Perform leak checks of both volumes of core module and airlock.	Ensure that atmospheric control system provides proper quantity and mix of atmospheric constituents to support life and that the leak rate from the module is within specification limits.	Pressurize core module with facility combination of O_2 and N_2 and verify specification leak rate and trace contaminates. Note: high-pressure tanks cannot contain high pressures in the MSOB		Facility source of N_2 and O_2 and distribution equipment; GSE I/F adapter; leak detection unit; trace contaminate detector.
Water management:					
Water storage and pump	Potable water servicing	Provide potable water supply to crew for orbital operations.	Purge and dry water management system prior to servicing using GN_2. To further ensure dryness of the water system, an ethyl alcohol flush procedure is required followed by a nitrogen purge. Ethyl alcohol is to be diluted with water at 25 percent by weight. Service system with a potable water transfer unit similar to the Apollo program unit - S14-119.		Facility nitrogen source and regulation equipment; water transfer unit similar to the Apollo program unit S14-119.
Special life support					
Fire control unit Fire detector	Verify functional performance of the fire detection and control unit.	To assure proper functioning of the system during orbital operations and that damage was not incurred during shipment to launch site.	Ascertain proper operation of monitor and alarm system with core module operating in conjunction with station module SM1-MS of the MSV or UTE.	X	
ISS					
Command and control and monitoring					
Portable control unit Local monitor and alarm	Verify functional performance of local monitor and alarm system, including portable fault isolation and maintenance displays and controls.	To ensure proper operation of these systems in orbit and prove no adverse effects in performance during shipment to the launch site.	Ascertain proper operation of monitor and alarm system with core module operating in conjunction with UTE or the MSV. This test can probably be run simultaneously with the special life support tests of the fire detection system.	X	
Communications:					
S-band antenna/ transponder	The communications systems will be activated and functional verifications will be performed by	To ensure that the communications system has not suffered damage during shipment and verify readiness for launch.	Tests will be conducted using the UTE RF equipment where practicable. RF energy absorption shields may be required to		RF-energy absorbing shields may be required. Specialized support stands may be

Table 2.2-1. Core Module (Cont)

System	Test and Operational Requirement	Purpose and Rationale	Test and Operational Technique	Support Requirement	
				UTE/MSV	GSE
VHF antenna/ transponder Wake-up receiver system	establishing RF communication with the local ground station.		prevent multipath RF reflections.		required for some antenna in 1-g field.
RCS					
Propellant feed controls:					
Valves Regulators	Verify proper operation of feed control valves & no leakage. Verify proper regulator operating pressures up to regulator lock-up.	To establish that handling during shipment from factory has not changed system performance or caused system leaks.	Pressurize system using GN_2 within system design tolerances. Check for leakage on all brazed joints and connections. Check for leakage past isolation valves, etc. Perform regulator flow and lock-up test.		GN_2 source and distribution; pressure regulator console similar to Apollo program unit C14-075.
Propellant accumulators O_2 H_2	The propellant accumulabors will have been checked at the factory, and it is assumed that there will be no degradation of performance; however, a check of the pressure integrity of the accumulators can be performed simultaneously with the propellant feed control tests above.	See above	See above		
Engines					
Engines and mounts	Engine injector valve leakage.	To verify no degradation of system performance resulting from shipment.	Install engine nozzle plug adapters and at design pressures verify specification leak rates at injector.	X	Recording devices similar to the C34-664 used in the Apollo program will be required. The nozzle adapters required will be similar to the A14-275.
	Valve signature (response) test	Verify correct operation of the RCS engine fuel and oxidizer solenoid valves. Opening and closing times of the solenoid valves are of particular interest.	The core module shall be configured for operation of the RCS engines using the normal control modes through the G&C system. SM-1MS will be utilized for control functions.		
	RCS/G&C polarity checks	To verify proper polarity of RCS engine response from the G&C system inputs.	This test can be combined with valve signature tests above.	X	Same requirement as for above test.
EPS					
Fuel cells Electrolysis units Inverters Regulators Lighting	Perform a functional evaluation of the fuel cell electrolysis units and inverters and regulators of the EPS.	Verify fuel cell, electrolysis, and peripheral equipment to ascertain that performance degradation has not occurred during shipment and that this equipment is ready for launch.	Utilizing GH_2 and GO_2, perform fuel cell flow checks using GSE control. Pressurization of the fuel cells must be accomplished using GN_2 prior to fuel cell start-up. The design specification for fuel cell operating limits will prevail. Loading of fuel cells can be accomplished using load banks. Water production from fuel cells and electrolysis rates can be compared with simulated electrical loads. Lighting will be evaluated by flight crew during the crew compartment fit and functional operations for crew/habitability.	X	Facility H_2/O_2 and regulation equipment; a GSE device for controlling valve functions; a load bank similar to the A14-074 used in the Apollo program is required.

Table 2.2-1. Core Module (Cont)

System	Test and Operational Requirement	Purpose and Rationale	Test and Operational Technique	Support Requirement	
				UTE/MSV	GSE
G&C					
Inertial reference:					
Strapdown IMU IMU preprocessor Optical reference: Horizon tracker optics Sextant/telescope Star tracker optics Navigation base Alignment links Momentum exchange Control moment gyros (CMG) CMG preprocessor	Strapdown IMU - perform functional test of the IMU to demonstrate its operating performance and interfaces with peripheral equipment. Demonstrate the ability of the optical equipment to supply valid reference data to the IMU. Conduct test to show that the CMG operating performance is per design specification. Control of equipment utilizing preprocessors will be accomplished via the ISS.	To demonstrate and verify that operating performance of the guidance and control equipment installed in the core module has not been degraded during shipment and that it is ready to support orbital operations.	These tests would be UTE of accomplished using the MSV.	X	
Crew/Habitability					
General and emergency equipment					
First aid kit	Crew compartment fit and functional (C^2F^2)	To familiarize flight crews with equipment stowage locations and peculiarities.	This operation would be accomplished by flight crew personnel during the C/O period. For the core module, this operation is not significant due to the small quantity of crew habitability equipment; however, for station modules this operation will be more significant.		
Structural/Mechanical					
Berthing and docking					
Mating rings/latches Utilities I/F	Verify docking and berthing interfaces between flight core module and MSV.	To ensure proper fit of interfaces including utilities.	The berthing interfaces should be checked against a master tool to ensure compatibility with the shuttle adapter.	X	Handling slings, facility crane (existing in MSOB), slings and dolly be required.
Secondary structure					
Airlocks Doors and hatches Windows Flexports	Perform leak checks of all airlocks, hatches, windows, and flexports.	To verify no shipment damage and that specification leak rate is not exceeded.	This test can be combined with the atmospheric control tests above.	X	Leak detection equipment similar to Apollo S34-160; Helium mass spectrometer
Cargo handling	Verify cargo loading rails and general handling equipment.	To ensure proper mating of cargo handling rails with cargo module and other station modules.	Will have been checked at the factory. Perform on MSV if inspection indicates a requirement exists	X	
Environmental shield					
Thermal shield	Emissivity measurements	Verify no degradation of thermal protection coating of structural surfaces.	Utilize emissivity measuring device at various points around external periphery of module.		Emissivity device like Apollo C14-410

Bus switching, regulation, lighting, and inverter load tests will be conducted in conjunction with the fuel-cell load tests.

EPS tests conducted during periods of fuel-cell inactivation will utilize facility power suitably connected to the core module electrical distribution system. The solar array system, which is discussed later in the test descriptions of the power module, will not be deployed in the 1-g gravity field. Thus, the primary source of power for the MSS (the solar array) will not be utilized during ground operations.

5. G&C. The guidance and control system verification tests will include the inertial reference, optical reference, and momentum exchange subsystems. These tests will be performed with the UTE.

   The inertial reference subsystem tests will include the strapdown IMU and the IMU preprocessor portion of the ISS. The IMU tests will be functional performance checks mostly concerned with determination of drift parameters after initial platform alignment. Optical interfaces with the IMU will be checked simultaneously with IMU tests.

   The optical reference tests will include the horizon and star tracker optics, sextant-telescope, navigation base, and alignment links. These tests will be combined with those previously described for the IMU where practical. The main purpose of these tests will be to demonstrate the ability of the optical equipment to supply valid reference data to the IMU.

   The momentum exchange system tests will be concerned with the control moment gyros (CMG) and the CMG preprocessor portion of the ISS. Tests of this equipment will be limited to an assessment of the control of the CMG through the ISS CMG preprocessor, and that the CMG operation is within design specification.

6. Crew habitability. The crew habitability equipment provided for the core module is minimal consisting of general emergency equipment. The small quantity of this equipment does not warrant a crew compartment fit and functional (C^2F^2) test; however, flight crews will have to be apprised of its stowage location.

7. Structural and mechanical system. Tests of elements of this system will pertain to berthing and docking, secondary structure, and environmental shield.

The berthing and docking tests of the mating rings and latches and utilities interfaces will have been performed at the factory during the initial mating of the core module with the acceptance fixture. At this time, functional tests will have been made of the latching mechanisms and the fit of the interface connections. The core module interface with the shuttle while in the orbiter cargo bay should be verified with a master tool or fixture representative of the shuttle berthing adapter.

The secondary structure tests of airlocks, doors and hatches, windows, and flexports will be confined to leak determinations past seals. Where practicable, the tests will be combined with the ECLSS atmospheric tests described previously. Cargo handling rails will be evaluated during their normal usage in handling equipment for the checkout tests.

The environmental shield tests will require emissivity measurements of the thermal shield to determine its reflective properties of certain wave lengths of solar radiation. These tests should be conducted near the end of the period of checkout testing, just prior to installation in the orbiter. The test purpose is to ascertain potential degradation of the thermal shield performance resulting from shipment and personnel handling during verification checkout tests and to establish a baseline reference of these properties just prior to launch.

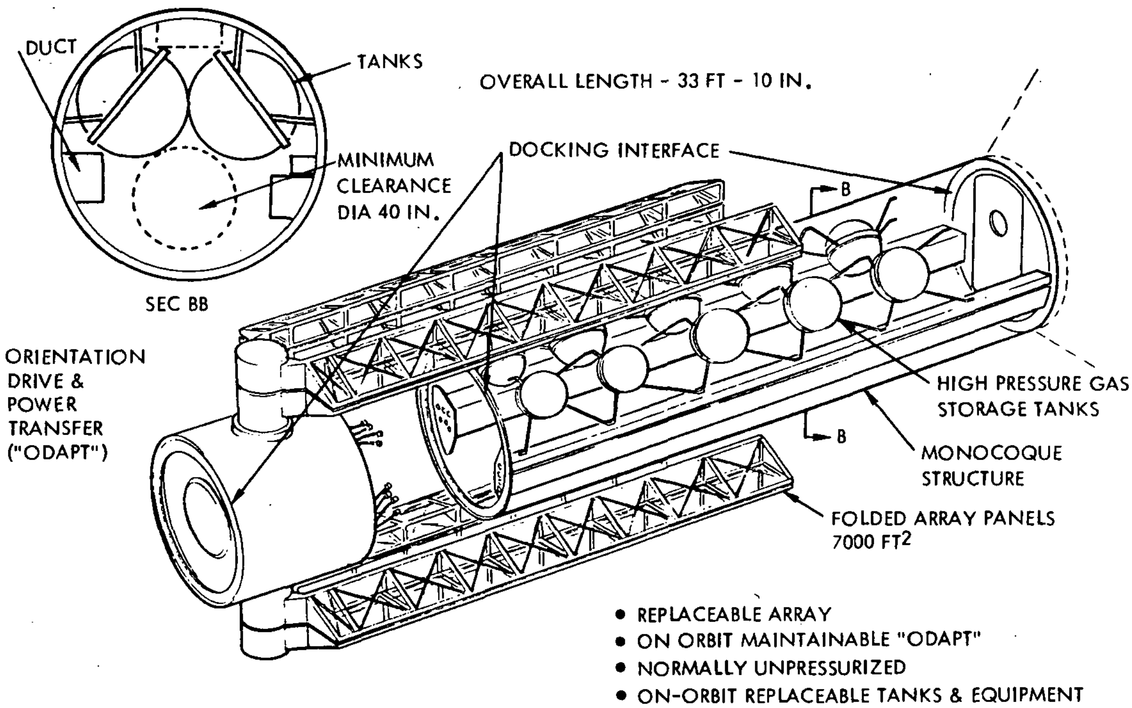
The tests are performed by calibrating readings at various points around periphery of the module, with a black-body reference to establish module radiation reflective properties.

Power Module

Configuration. The power module supplies the primary power for MSS operation utilizing a solar array power system of approximately 7000 square feet for the initial station (10,000 square feet for the growth station).

When docked to the +X docking port of the core module, the power module becomes part of volume 1 of the core. The power module contains four, one O_2 and three N_2, high-pressure (3000-psi) tanks for repressurization of one module of the station. The solar arrays in the retracted position are within the 14-foot envelope per design specification, and the turret/array combination is removable for array replacement. Figure 2.2-7 shows the power module and the major equipment installations. The figure also indicates the overall dimensions of the power module.

The importance of the power module in the initial station buildup justifies it to be the second module in the launch sequence.



MAJOR EQUIPMENT INSTALLATIONS

AUDIO/VIDIO UNIT (1)
FIRE CONTROL UNITS (2)
O_2 HIGH-PRESSURE TANKS (1)
N_2 HIGH-PRESSURE TANKS (3)

FIRE DETECTOR
LOCAL MONITOR ALARM
TV CAMERA COLOR
FIRST AID KIT

SOLAR ARRAY
SA DRIVE & PWR XFER

Figure 2.2-7. Power Module

Systems Tests. The checkout and systems verification tests for the power module will be accomplished on the ECLSS, ISS, EPS, crew habitability, and structural and mechanical systems. Table 2.2-2 is a summary of the tests to be performed on the power module. A brief description of the tests to be performed per system is provided below:

1. ECLSS. The gaseous storage and special life support subsystems of the ECLSS will be subjected to verification tests with the UTE.

   The gaseous storage system is comprised of three N_2 (3000-psi) and one O_2 (3000-psi) tanks, valves, plumbing, etc. It will be necessary to conduct leak checks of this system; however, safety limitations imposed on the checkout facility (MSOB) preclude pressures that will create overpressures in excess of 3 psi in case of accidental rupture of the O_2/N_2 high-pressure tanks. Therefore, the leak checks must be performed at less than or equal to 25-percent design burst pressures for the tanks (less than or equal to 750 psi). A suitable leak detection device, such as a mass spectrometer or gas chromatograph, can be used to detect leaks at all welds, valves, fittings, etc. Loading of the O_2/N_2 gases to full pressures will be deferred until the orbiter arrives at the pad with the power module installed in the cargo bay. An interface with the shuttle will be required for loading high-pressure gases, including monitor and control functions through the shuttle launch control system. The interfaces are defined in more detail later in this report.

   The special life support subsystems tests of the fire control and detector units will be functional checks of the systems to verify proper operation with interfacing elements of the ISS, where practical.

2. ISS. The command and control and monitoring and communications subsystems verification tests will be performed utilizing the UTE.

   The command and control and monitoring subsystem will be restricted to functional performance tests of the local monitor and alarm subsystem via its interfaces through the ISS/UTE with other subsystems of the power module.

   The communications tests will consist of functional performance of the audio-video unit, color TV camera, and hardware intercom system.

3. EPS. The EPS system verification tests of primary power generation, and lighting subsystems will be done with the power module mated to the UTE.

Table 2.2-2. Power Module

System	Test and Operational Requirement	Purpose and Rationale	Test and Operational Technique	Support Requirement	
				UTE/MSV	GSE
ECLSS					
Gaseous storage:					
High-pressure gases (3) N_2 3000 psi (1) O_2 3000 psi	Perform high-pressure gas system leak checks (MSOB) using pressures less than or equal to 25-percent design burst. Load high-pressure gases at pad for launch.	To verify no leaks in high-pressure gas system resulting from shipment. Loading of high-pressure gases to full tank pressures must be accomplished at the pad from safety considerations.	Pressurize tanks and systems with N_2 and O_2 to 25 percent design burst. Use suitable leak detecting device (mass spectrometer or equivalent) to check all welds and valves for leaks (MSOB). Full pressure loading will be accomplished at the pad with power module loaded in orbiter.		Facility O_2 and N_2 pressurization sources and regulation at MSOB and pad. High-pressure ground controlled loading device similar to Apollo S7-41.
Special life support:					
Fire control Fire detector	Verify functional performance of the fire detection and control unit.	(Same as core module)	Ascertain proper operation of monitor and alarm system.	X	
ISS					
Command and control and monitoring					
Local monitor and alarm	Verify functional performance of local monitor and alarm system.	To ensure operation of this system in orbit and that degradation of performance during shipment has not occurred.	Check monitor and alarm system with UTE or module operating in conjunction with MSV.	X	
Communications					
Audio-video unit Hardwire intercom TV camera - color	Verify the operating performance of these systems.	To ensure that performance has not degraded resulting from shipment and handling.	Check TV and intercom systems with power module operating.	X	
EPS					
Primary power generation					
Solar array	Tests of the solar array will not be accomplished due to its structural limitations in a 1-g environment. However, it will be subjected to handling operations.	Handling operations cannot be avoided during launch preparations of the solar array.	Handling operations will be performed on the solar array during off-loading, C/O, and installation in orbiter.	X	A facility power source is required because the solar array will not be used during ground operations.
Orientation drive and power transfer	An orientation drive and power transfer (ODAPT) functional check should be performed.	The ODAPT will be subjected to functional checks to verify no damage during shipment.	The ODAPT will be functionally checked with the power module operating in conjunction with the MSV or UTE.		Special slings dollies and transporter will be required to handle the solar array and power module.
Lighting					
Internal External	Lighting, external and internal, will be functionally verified.	Lighting, including circuitry, switches, greakers, lamps, etc., should be functionally verified against shipment damage.	Lighting will be evaluated by flight crews during normal C/O operations.		
Crew Habitability					
General and emergency equipment					
First aid kits	Crew compartment fit and functional (C^2F^2)	To familiarize flight crews with equipment stowage locations and peculiarities.	This operation would be accomplished by flight crew personnel during the C/O period. For the power module, this operation is not significant because of the small quantity of crew habitability equipment; however, for station modules this operation will be more significant.		

Table 2.2-2. Power Module (Cont)

System	Test and Operational Requirement	Purpose and Rationale	Test and Operational Techniques	Support Requirement	
				UTE/MSV	GSE
Structural and Mechanical					
Berthing and docking					
Mating rings and latches Utilities I/F	Verify docking interfaces between flight power module and MSV.	To ensure proper fit of interfaces including utilities.	The berthing interface should be checked against a master tool to ensure compatibility with the shuttle adapter.	X	Handling slings, facility crane (existing in MSOB), slings, and dolly will be required.
Secondary structure					
Doors and hatches Windows	Perform leak checks of all doors and hatches and windows (volume 1).	To verify specific leak rate is not exceeded and no shipment damage.	Using MSV core module or UTE/adapter pressurize module and check dock berthing ports to verify specific leak rate is not exceeded. Delta P across structure that is experienced in free space is probably not safe in ground operations, so extrapolation of test data may be necessary.	X	Pressurization unit similar to the Apollo S7-41 will probably be required.
Cargo handling	Verify cargo loading rails and general handling equipment.	To ensure proper mating of cargo handling rails with core module.	Will have been checked at factory. Perform on MSV if inspection indicates a requirement exists.	X	
Environmental shield					
Thermal shield	Emissivity measurements	Verify no degradation of thermal protection coating of structural external surfaces.	Utilize emissivity measuring device at various points around external periphery of module.		Emissivity device like Apollo C14-410

The primary power generation subsystem elements contained in the power module are the solar array and the orientation drive and power transfer (ODAPT) subsystems. The deployment of the solar array is restricted to usage in orbit at zero-g conditions for structural reasons; thus, the arrays will not be subjected to the ground tests at the launch site. The ODAPT will be functionally checked to verify proper movements and response from its control elements. The tests will be done with the solar array disconnected mechanically from the ODAPT.

The internal and external lighting system, including circuitry, switches, breakers, lamps, etc, will be verified functionally. The input power source for the power module tests will be from the facility utilizing a GSE adapter.

4. Crew habitability. As in the case of the core module, the power module does not contain enough crew habitability equipment to warrant the performance of a crew compartment fit and functional test (C^2F^2), but flight crews should be aware of the stowage requirements for such equipment. Table 2.2-2 shows the only item to fall in this category is general and emergency equipment comprised of first aid kits.

5. Structural and mechanical system. The system verifications tests for the power module are essentially the same as those specified for the core module. Refer to the core module description of these tests.

Station Module (SM-1)

Configuration. The station module structural arrangement is shown in Figure 2.1-32 and is essentially the same for all station modules. Figure 2.1-32 also illustrates the external dimensions applicable to all station modules. Figure 2.2-8 is a schematic representation of station module SM-1.

The crew and control station module (SM-1) contains a commander and executive-type stateroom and two crew staterooms. These are provided in a split-level arrangement as shown in the figure. The waste management equipment is located below deck near the personal hygiene area. The control center, data analysis, and the photo laboratory occupy the remainder of the upper deck area.

The major equipment allocations for all of the station modules is provided in Table 2.2-3. The equipment items are listed per system elements for the initial station.

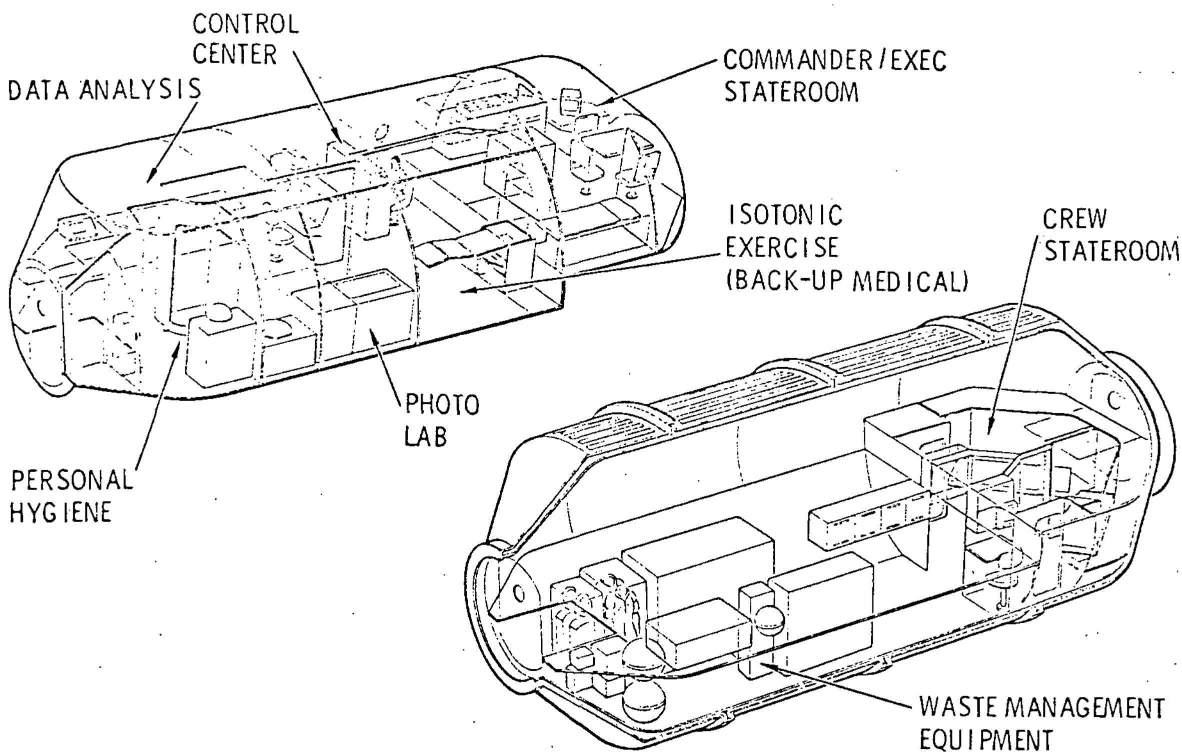


Figure 2.2-8. Module 1 Control/Crew

Station module SM-1 is the third module launched in the initial station buildup and affords the first orbital capability for flight crew control.

Table 2.2-3. Subsystem Major Equipment Allocation Initial Station Modules

Equipment Item	Station Module			
	SM-1	SM-4	SM-3	SM-2
ECLSS				
Trace contaminate			X	X
Sink	X	X	X	X
Water storage	X	X		
Potable water receovery	X	X		
CO_2 management			X	X
Pressure control			X	X
Water electrolysis			X	X
Humidity control			X	X

Table 2.2-3. Subsystem Major Equipment Allocation
Initial Station Modules (Cont)

Equipment Item	Station Module			
	SM-1	SM-4	SM-3	SM-2
Contamination control			X	X
Vapor compression			X	X
Water purity monitor	X	X		
Dry john	X	X		
Urinal	X	X		
Shower		X		
Vacuum cleaner			X	X
Pumpdown unit			X	X
Local charcoal canisters	X	X	X	
Sensible heat exchanger and fans	X	X	X	X
Trash processing			X	X
Temperature control unit	X	X	X	X
Radiators	X	X	X	X
Coldplates	X	X	X	X
Water loop plumbing	X	X	X	X
Resistance oven			X	
Reconstitution unit		X	X	
Refrigerator			X	
Freezer			X	
Microwave oven		X	X	
ISS				
Central processor	X	X		
Control console	X	X		
Commander's D/C console	X			
Microfilm viewer	X	X		
Parabolic antenna	X	X		
Remote terminal unit	XQ	X		
Audio recorder	X	X		
Remote processing units	X	X	X	X
Local monitor and alarm units	X	X	X	X
Audio-video unit	X	X	X	X
TV camera	X	X	X	X
TV monitor	X	X	X	X
Semidirectional antenna	X	X	X	X

Table 2.2-3. Subsystem Major Equipment Allocation
Initial Station Modules (Cont)

Equipment Item	Station Module			
	SM-1	SM-4	SM-3	SM-2
Crew habitability				
Utensil and food storage		X	X	
PGA (2)	X	X		
PLSS (2)	X	X		
First aid kit	X	X	X	X
Fire control unit	X	X	X	X
Portable O_2 bottles and masks	X	X	X	X
EPS				
Electrolysis units	X			
Secondary bus	X	X	X	X
Interior lighting	X	X	X	X

Systems Tests. The checkout and systems verification tests for the crew and control station module (SM-1) will be accomplished on the ECLSS, ISS, EPS, crew habitability, and structural and mechanical subsystems. Table 2.2-4 is a summary of the tests to be performed on SM-1. A brief description of the tests per system is provided below:

1. ECLSS. The CO_2 management, atmospheric control, thermal control, water management, waste management, hygiene, and special life support subsystems will be subjected to verification tests utilizing the UTE.

   The CO_2 management subsystem tests will be minimal for SM-1, including the CO_2 sensor unit and local charcoal filtering. Functional performance of this equipment will be assessed with tests performed in parallel with atmospheric control tests when feasible.

   Atmospheric control subsystem tests of the vent fans, pressure relief, explosive atmosphere detector, and pressure sensor subsystems will be done. Pressurization, circulation, and venting performance of the atmospheric control subsystem will

Table 2.2-4. Station Module (SM-1)

System	Test and Operational Requirement	Purpose and Rationale	Test and Operational Technique	Support Requirement	
				UTE/MSV	GSE
ECLSS					
CO_2 management					
CO_2 sensor unit Local charcoal	Verify CO_2 sensor unit and CO_2 reduction capability.	To ensure post-shipment performance is within specification.	Perform these test using the MSV or UTE, combining them with the atmospheric control tests where feasible.	X	
Atmospheric control					
Vent fans Pressure relief system Explosive atmos. detector Pressure sensors	Verify pressurization, circulation and venting performance of the atmospheric control system.	To ensure pressure relief system and vent fan performance has not degraded resulting from shipment and that system is ready for launch.	Combine these tests with above, if practicable.	X	Leak detection equipment such as the S34-160.
Thermal control					
Sensible heat exchanger and fan assembly Water pump package Freon/H2O intercooler Freon pump package Freon reservoir	Verify the thermal control system performance.	To verify that system performance is ready for launch and has suffered no degradation from shipment.	Perform these tests using the MSV or UTE if possible; some ground equipment may be necessary as indicated at right.	X	Freon circulation and ground cooling unit similar to the *Apollo S14-121 unit* may be required for these tests.
Water management					
Water reclamation unit Vent accumulator Vent accumulator pump Potable H_2O tanks Purity monitor system	Verify the functional performance of these systems.	To ensure no post-shipment damage and readiness to support launch and servicing where necessary.	Perform tests using the SM-1 in conjunction with MSV or UTE.	X	If water servicing is required, a type similar to the Apollo S14-119 may be feasible.
Waste management					
Fecal collection Urine collection	Verify functional performance of these systems where practicable.	To ensure launch readiness and no shipment damage.	Perform tests using MSV or UTE.	X	
Hygiene					
Shower Sink	Verify functional performance of this equipment including water supply systems.	To ensure launch readiness and no shipment damage.	Perform tests using MSV or UTE.	X	
Special life support					
Fire extinguisher package Fire detectors	Verify functional performance of the fire detection and fire extinguisher package.	To verify no shipment damage and to ensure systems are ready for launch.	Ascertain proper system functioning.	X	
EPS					
Energy storage					
Electrolysis unit	System servicing and functional performance.	To prepare system for launch and to ensure no shipment damage.	Servicing operation may require special ground equipment.	X	Water servicing unit similar to Apollo S14-119 unit
Power conditioning					
Secondary bus	Perform functional verification of secondary bus control and operation.	Verify that no damage to the EPS secondary bus switching and control occurred during shipment and that system is ready for launch.	Bus switching is a normal part of EPS testing.	X	
Lighting					
Interior lights	Functionally check all lighting in as near to orbital usage condition as possible.	Lighting verification should be accomplished to ensure no shipment damage.	Crew participation would be desirable for the lighting evaluation tests.		

Table 2.2-4. Station Module (SM-1) (Cont)

System	Test and Operational Requirement	Purpose and Rationale	Test and Operational Techniques	Support Requirement	
				USV/MSV	GSE
ISS					
Command and control and monitoring					
Operational control console 1 Commander's control console Emergency G&C control Portable control console Local monitor and alarm Microfilm projector	Perform a functional verification of the operating performance of the command and control and monitoring system.	To ensure that system performance has not degraded as a result of shipment and to verify systems readiness for launch.	The tests of the command and control and monitoring system will be accomplished utilizing the MSV or UTE. Crew participation will probably be advantageous during portions of this test.	X	
Data processing assembly					
Data bus control Central timing unit Central processor Data analysis lab Photo processing Photo storage	Verify the operating performance of the data processing assembly.	To ensure system readiness for launch and no shipment damage.	These tests may be combined with the command and control and monitoring tests above.	X	
Communication (External)					
K_u-band antenna K_u-band antenna mounted electronics K_u-band nonintegrated electronics S-band fixed parabolic antenna S-band transponder VHF antenna VHF transponder	The external communications system antenna pattern tests will have been accomplished at the factory; however, some functional performance tests involving transmissions of RF energy may be required at the launch site.	To ensure that the communications system has not suffered damage during shipment, and verify readiness for launch.	Tests will be conducted using the MSV or UTE. RF energy absorption shields may be required to prevent multipath RF reflections.	X	RF energy absorbing shields may be required. Specialized support stands may be required for some antenna in 1-g field.
(Internal)					
Communications rack subassy Recording subassy Audio-video unit Hardwire intercomm TV camera - color TV camera - black and white TV monitors	The internal communications system will be functionally tested, including all video-audio systems. Flight crew systems hardware possessing interfacing systems such as EVA/IVA suits communication devices should be included in these tests.	To ensure internal communications system performance is ready for launch including interfacing crew systems personnel equipment.	These tests will be performed utilizing the MSV or UTE.	X	
Software assembly					
Computer programs Microfilm Printer/facsimile paper	The software programs will be verified during the normal checkout of the information subsystem (ISS). The microfilm and printer facsimile paper storage provisions will be validated.	Software programs will be verified to be ready for launch. Storage of software programs, microfilm and printer paper should be part of the flight crews C^2F^2.	Perform these tests during normal checkout of the ISS using the MSV. Flight crew participation will be required for the C^2F^2 portion.	X	
Crew Habitability					
General and emergency equipment					
PGA PLSS First aid kit Fire control unit Portable O_2 bottles and masks Backup medical and exercise area Commander's stateroom Crew staterooms	The pressure garment assembly (PGA), portable life support system (PLSS), and O_2 bottles and masks are part of the crews personnel equipment which will require interface tests with the MSS. The remaining equipment is mostly concerned with crew compartment fit and functional (C^2F^2) tests performed by the flight crews and general livability.	The interface tests of the PGA, PLSS and O_2 bottles and masks are required to ensure proper functioning of these items with the MSS systems. The C^2F^2 tests are necessary to familiarize flight crews with equipment stowage locations and peculiarities.	Tests to be performed utilizing the MSV or UTE.	X	Facility source for breathing oxygen may be required. PGA O_2 suit loop C/O unit similar to Apollo A14-033 unit may be required.

Table 2.2-4. Station Module (SM-1) (Cont)

System	Test and Operational Requirement	Purpose and Rationale	Test and Operational Techniques	Support Requirement	
				USV/MSV	GSE
Structural and Mechanical					
Berthing and docking					
Mating rings/ latches Utilities I/F	Verify docking and berthing interfaces between modules.	To ensure proper fit of interfaces, including utilities.	The berthing interfaces should be checked against a master tool to ensure compatibility with the shuttle berthing adapter.	X	Handling slings and dolly to conduct ground docking tests will be required. Facility crane (existing in MSOB) will be required.
Secondary structure					
Airlocks Doors and hatches Windows Flexports	Perform leak checks of all airlocks, hatches, windows, and flexports.	To verify no shipment damage and that specification leak rate is not exceeded.	This test can be combined with atmospheric control tests above.	X	Leak detection equipment similar to the Apollo S34-160. Helium mass spectrometer is required.
Cargo handling	Verify cargo loading rails and general handling equipment.	To ensure proper mating of cargo handling rails with core module.	Will have been checked. at the factory. Perform on MSV if inspection indicates a requirement exists.	X	
Environmental shield					
Thermal shield	Emissivity measurements	Verify no degradation of thermal protection coating of external structural surfaces.	Utilize emissivity measuring device at various points around external periphery of module.		Emissivity device like Apollo C14-410

be evaluated. Pressurization requirements of SM-1 will require the same facility callouts for O_2 and N_2 described for the core module atmospheric control tests.

Thermal control subsystem tests will include the sensible heat exchanger and fan assembly, water pump package, freon/water intercooler, freon pump package, and freon reservoir. Tests will be performed using UTE, but it is recognized that some of the thermal control subsystem elements normally functioning in the complete station may need to be simulated. It also is recognized that heat rejection to free space will be different from that during ground operations; therefore, augmentative cooling units similar to the Apollo program S14-121 refrigeration unit may be required.

Water management subsystem tests will be concerned with the water reclamation unit, vent accumulator and pump, potable water tanks, and purity monitoring subsystem. Functional performance evaluations will be made of these subsystems during normal operation. Pretest water servicing may be required, utilizing a water servicing unit similar to the Apollo S14-119 unit. The reclamation unit tests will require a vacuum source to operate the vapor compression still, if such operation is feasible during ground testing.

Waste management subsystem tests involving the fecal and urine collection systems will be functionally evaluated where practicable. Waste constituents other than feces and urine would probably be utilized for these tests.

Hygiene subsystem tests of showers and sinks would be functional in nature.

Special life support subsystem tests of the fire extinguisher package and detectors would be confined to functional category. Verification of the detector performance would be necessary, but actuation of the fire extinguisher would not be required. If safety considerations warrant the actuation of the fire extinguisher package during tests, GSE units could be employed containing inert gases.

2. ISS. Verification tests will be performed on the ISS pertinent to the command and control and monitoring, data processing assembly, external and internal communications, and the software assembly. These tests will be performed utilizing SM-1 in conjunction with the UTE.

The command and control and monitoring subsystem tests will include the No. 1 operational console, commander's control console, emergency G&C control, portable control console, local monitor and alarm, and microfilm projector. The tests of this subsystem will be functional in nature, amounting to an assessment of the input and output functions of the various control consoles and an evaluation of generated data.

The data processing assembly includes the data bus control, central timing unit, central processor, data anslysis laboratory, photo processing, and storage. The tests of this subsystem will include all of these elements where practical. In some cases, the tests may be combined with the above command and control and monitoring subsystem tests.

The communication subsystem verification tests will be performed in two categories: external communications consists of the k_u-band antenna and antenna-mounted electronics, nonintegrated electronics, S-band fixed parabolic antenna and transponder, and the VHF antenna and transponder. Antenna radiation patterns are a function of antenna design, and the determination of these patterns will be accomplished at the factory; however, functional tests may require transmitting RF energy. Antenna tests involving RF transmissions will probably require absorption shields (GSE) to prevent multipath reflections.

The internal communications consists of the communications rack subassembly, recording subassembly, audio-video unit, hardware intercommunications, TV cameras, black and white and color, and TV monitors. These subsystems will be subjected to system functional checks and, in cases where interfaces occur with personnel equipment such as EVA/IVA suit communications, flight components should be part of the test.

The software assembly comprises the computer programs, microfilm, and printer/facsimile paper. The computer programs will be checked out during normal verification checks of the ISS and other systems. The storage requirements associated with the software assembly, particularly the microfilm and printer/facsimile paper, will necessitate performing a crew compartment fit and functional test (C^2F^2) in order to familiarize flight crews with storage locations.

3. EPS. The system verification tests of the EPS will deal with the energy storage, power conditioning, and lighting subsystems. Utilization of the UTE will be a necessary requirement for these tests.

   The energy storage subsystem for SM-1 will involve system servicing and functional tests of the electrolysis units. Because the electrolysis units are part of the integrated water storage, including potable water, it will be necessary to service the units with contaminate-free, deionized water utilizing GSE similar to the Apollo program S14-119 water servicing unit. The functional tests of the electrolysis units will be concerned with rates of GH_2 and GO_2 production, along with water and electrolysis current input requirements.

   Power conditioning tests will be confined to secondary bus control and operation, including switching and isolation.

   Lighting tests of the interior lights will be of a functional nature with flight crew participation as a desirable goal. It also may be desirable to combine these tests with the crew habitability C^2F^2 tests specified in item 4.

4. Crew habitability. The crew habitability subsystem verification tests pertain mainly to personnel equipment in the category of general and emergency equipment. This category includes the pressure garment assembly (PGA), portable life support system (PLSS), first aid kit, fire control unit, and portable O_2 bottles and masks. In addition, the crew habitability subsystem includes the backup medical and exercise area and the commander's and crew staterooms.

   Personnel equipment previously mentioned will require interface tests with the MSS, especially the PGA, which will require a facility breathing oxygen supply and probably a PGA O_2 suit loop checkout unit similar to the Apollo program A14-033 unit.

   All of the crew habitability subsystem equipment will need to be subjected to the C^2F^2 tests to familiarize the flight crews with equipment locations and storage peculiarities. These tests also will be necessary for all equipment stowed in the medical and exercise area and the commander's and crew staterooms. Flight crew participation is a requirement for conducting these tests.

5. Structural and mechanical subsystem. The subsystem verification tests for the structure and mechanical subsystem will be similar to those discussed previously for the flight core module.

Station Module (SM-2)

Configuration. The laboratory/atmosphere management station module (SM-2) is shown in Figure 2.2-9. The laboratory module houses the air revitalization equipment (CO_2 management and atmosphere control) for volume 2 of the MSS. Module SM-2 contains the mechanical and optical electrical general purpose laboratory (GPL) area and provides an area for the earth observation laboratory and biosciences (although not simultaneously). The nadir airlock is located at the end of this module.

Some of the SM-2 GPL typical operations are shown in Figure 2.2-10. The installation of earth observation equipment is indicated. Stowage of sensors not in use is provided, and control of the experiment is accomplished through a portable control unit of the ISS. SM-2 is the fourth module launched in the initial station buildup.

Systems Tests. The systems verification tests for the laboratory and atmosphere management station module (SM-2) will include the ECLSS, ISS, EPS, crew habitability, and structural and mechanical subsystems. Table 2.2-5 is a summary of the tests to be performed on SM-2. A brief description of the tests, per system, is provided below:

1. ECLSS. The gaseous storage, CO_2 management, water management, atmospheric control, thermal control, waste management, hygiene, and special life support subsystems will undergo verification tests utilizing the UTE.

   The pumpdown units are the only elements of the gaseous storage subsystem contained in SM-2. An operational check of the functional performance of this equipment may not be too practical during ground operations for two reasons. First, the particle count of the air may be too high, even though it would be no worse than the ambient of the MSOB, which is controlled to 100,000 particles less than or equal to 5 microns and 700 particles more than or equal to 5 microns per cubic foot. Second, the Delta P across the module shell would be opposite to that occurring in free space, unless the module were pressurized above 14.7 psi some small amount prior to start of pumpdown. In any event, the performance of this test would be accomplished to levels that indicate proper system operation only.

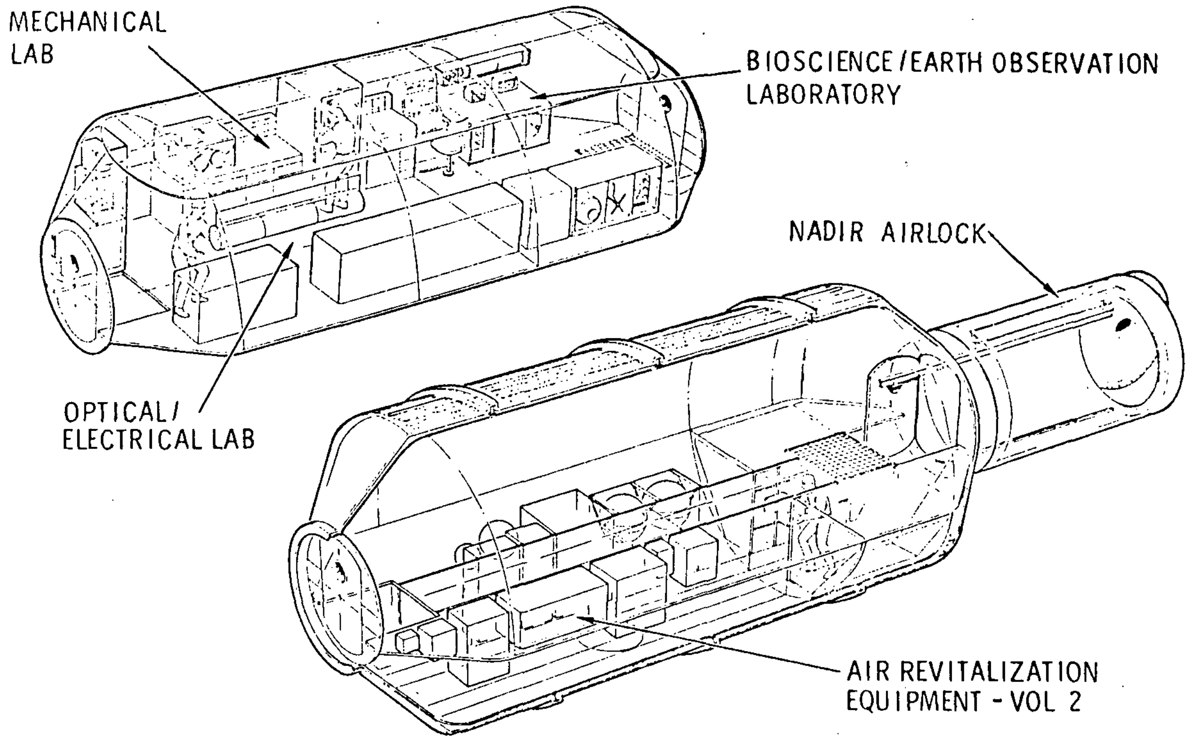


Figure 2.2-9. Laboratory/Atmosphere Management—Module 2

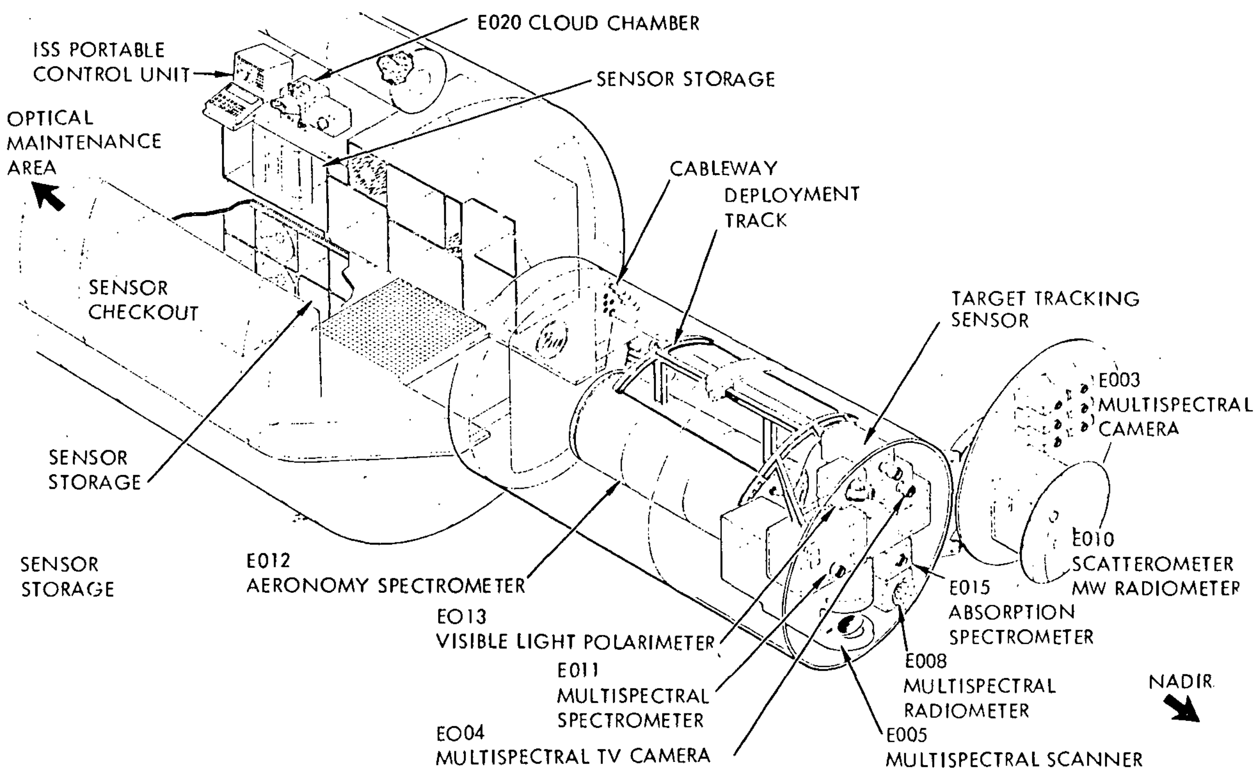


Figure 2.2-10. SM-2 GPL Typical Operations

Table 2.2-5. Station Module (SM-2)

System	Test and Operational Requirement	Purpose and Rationale	Test and Operational Technique	Support Requirement UTE/MSV	Support Requirement GSE
ECLSS					
Gaseous storage					
Pumpdown units	Conduct a functional performance C/O of the pumpdown units.	To verify no shipment damage resulting in loss of performance and that system is ready for launch.	Perform a pumpdown of non-contaminated atmosphere to levels that indicate proper functioning of system.	X	
CO_2 management					
CO_2 removal unit* CO_2 reduction unit* CO_2 sensor unit	Verify CO_2 reduction/removal to specification PPC02 tolerances.	To ensure system performance after shipment and readiness for launch.	Perform C/O and monitor PPC02 via the CO_2 sensor units in SM-2 and checkout equipment.	X	
Vent gas accumulator* Vent gas accumulator pump* Local charcoal	Verify functional performance of vent gas pump and accumulator.	To ensure system readiness for launch.	Perform these tests in conjunction with CO_2 reduction/removal tests above. Note: CH_4 (methane) output of Sabatier CO_2 reduction unit will require a vent stack system in the MSOB to disperse this hazardous gas in an area that would not be dangerous to personnel.	X	Facility vent stack system or toxic vapor disposal unit will be required in the MSOB. A unit similar to the Apollo S14-060 TVD may be adequate.
H_2O management					
Water accumulator* V/C H_2O feed pump*	Verify the performance of the water accumulator and vapor/compression water	To ensure systems performance readiness for launch.	Perform tests utilizing the MSV or UT in conjunction with SM-2.	X	
Atmospheric control					
Vent fans Humidity control unit* Pressure relief system Partial pressure O_2 control* Pressure sensors Contaminant control unit* Gas monitoring bacteria detector* Explosive atmos detector	Same test requirement as for SM-1	← Same as SM-1 →			
Thermal control					
Sensible heat exchanger and fan assy	← Same as SM-1 →				
Waste management					
Trash processing	Perform functional operation check of this portion of waste management system if practicable.	Verify proper operation and readiness to support launch.	Perform in conjunction with MSV or UTE.	X	
Hygiene					
Galley and lab sink	← Same as SM-4 →				
Vacuum cleaner	Perform functional operational check. Also, may be an item for C^2F^2.	Verify readiness for launch. Acquaint flight crew with location and storage requirement.	Functional	X	
Special life support					
Fire extinguisher package Fire detectors	← Same as SM-1 →				
Lithium hydroxide (LiOH) canisters	Perform fit check and storage location tests with flight crew participation (C^2F^2).	Familiarize flight crew with storage locations and fit peculiarities.	Functional	X	

*These items comprise the operational systems for SM-2; like standby systems are contained in SM-3.

Table 2.2-5. Station Module (SM-2) (Cont)

System	Test and Operational Requirement	Purpose and Rationale	Test and Operational Technique	Support Requirement	
				UTE/MSV	GSE
Lithium hydroxide assy Lithium hydroxide storage					
EPS					
Power conditioning					
Secondary bus					
Lighting	← Same as SM-1 →				
Interior lights					
ISS					
Command and control and monitoring					
Local monitor and alarm Microfilm projector	← Same as SM-1 →				
Communications (Internal)					
Audio-video unit Hardwire intercomm	← Same as SM-1 →				
Crew habitability					
General and emergency equipment					
First aid kit Fire control units Portable O_2 bottles and masks	← Same as SM-1 →				
Food management					
Galley (backup)	Perform functional operation check of installed equipment (e.g., ovens, sinks, etc.,). Also, perform C^2F^2 of food storage location and peculiarities with flight crew participation.	Familiarize flight crews with storage locations and peculiarities. Verify readiness for launch.	Functional	X	Food storage facility will be required similar to Apollo program Flight Crew systems laboratory. Some special food handling equipment may be required such as handcars, dollies, etc.
Structural and Mechanical					
Berthing and docking					
Mating rings and latches Utilities I/F	Verify docking berthing interfaces between modules.	To ensure proper fit of interfaces including utilities.	The berthing interfaces should be checked against a master tool to ensure compatibility with the shuttle berthing adapter.	X	Handling slings and dolly to conduct gnd docking tests will be required. Facility crane which is available in MSOB will also be required.
Secondary structure					
Airlocks Doors and hatches Windows Flexports	Perform leak checks of all airlocks, hatches, windows, and flexports.	To verify no shipment damage and that specific leak rate is not exceeded.	This test can be combined with atmospheric control tests above using MSV.	X	Leak detection equipment similar to Apollo S34-160; helium mass spectrometer
Cargo handling	Verify cargo loading rails and general handling equipment.	To ensure proper mating of cargo handling rails with cargo module and between modules.	Will have been checked at factory. Perform on MSV if inspection indicates a requirement exists.	X	

Table 2.2-5. Station Module (SM-2) (Cont)

System	Test and Operational Requirement	Purpose and Rationale	Test and Operational Technique	Support Requirement	
				UTE/MSV	GSE
General purpose laboratory furnishings					
Experiment storage	C^2F^2 with flight crew participation	To familiarize flight crew with storage locations and anomalies.	Functional	X	
Mechanical and electrical equipment Optical equipment	Verify functional performance of equipment with interfacing MSS utility requirements.	To ensure satisfactory operation of equipment and readiness for launch.	Functional	X	
Environmental shield					
Thermal shield	Emissivity measurements	To verify no degradation of thermal protection coating of structural surfaces.	Utilize emissivity measuring device at various points around periphery of module.		An emissivity device similar to Apollo C14-410 could be utilized for these measurements.

The CO_2 management subsystem for SM-2 (and SM-3) is more complicated than that of the other modules and is comprised of CO_2 removal, reduction and sensor units, vent gas accumulator, and pump and local charcoal subsystems. The CO_2 Sabatier reduction unit utilizes GH_2 as a reactant with CO_2 to produce water, methane (CH_4) and CO_2 (because the process utilizes an excess of CO_2). Therefore, functional verification of the performance of the CO_2 reduction and removal system during operation with the MSV will require a vent gas or toxic vapor disposal unit in the MSOB. CO_2 sensor operation can be evaluated by monitoring the variation of CO_2 in the SM-2 module and MSV elements. Vent gas accumulator and pump and local charcoal tests will be combined with the reduction and removal tests. The items shown in Table 2.2-5 affixed with an asterisk are the operational systems; identical backup systems are contained in SM-3.

The water management subsystem, consisting of the water accumulator and vapor/compression water feed pump, will be functionally evaluated for proper operation.

The atmospheric control subsystem, which, for SM-2, includes vent fans, humidity control unit, pressure relief system, partial pressure O_2 control, pressure sensors, contaminant control unit, gas monitoring/bacteria, and explosive atmosphere detectors, will be functionally tested.

Thermal control subsystem verification tests for SM-2 are minor and will consist of functional checks of the sensible heat exchanger and fan assembly during operation with interfacing elements of the MSV. The tests performed will be similar to those accomplished on flight module SM-1.

Waste management subsystem tests will consist of functional checks of the trash processing system if such tests appear practical. Otherwise, the tests may be confined to verification of equipment operation without actually attempting to process trash. The hygiene subsystem verification tests will be concerned with functional operating checks of the galley and laboratory sink and vacuum cleaner.

The final subsystem of the ECLSS, special life support, will include verification tests of the fire extinguisher package and detectors and the lithium hydroxide assembly, canisters, and storage. Functional checks of the fire extinguisher package may involve false stimulation of a fire through the detection system and activation of the fire extinguisher package via the ISS. If activation of the fire extinguisher package is necessary, GSE units filled with an inert gas could be used.

The lithium hydroxide equipment tests will be functional where practical but will definitely include a crew compartment fit and functional check to familiarize flight crews with storage locations.

2. EPS. Power conditioning and lighting are the only elements that make up the EPS subsystem for SM-2. Power conditioning tests will be confined to secondary bus control and operation, including switching and isolation. Lighting tests of the interior lights will be restricted to a functional evaluation with flight crew participation as a desirable goal.

3. ISS. Verification tests of the ISS for similar systems to those contained in SM-1 will be the same as those specified for SM-1.

4. Crew habitability. The crew habitability subsystem tests of SM-2 will be identical to those called out for SM-1, because the equipment installations are essentially the same. Food management is one element of the crew habitability subsystem not contained in SM-1; specifically, the backup galley, which will require a C^2F^2 for good storage with flight crew participation. Functional checks of the backup galley will be performed on such items as ovens, sinks, etc.

5. Structural and mechanical subsystem. The tests of this subsystem for equipment items that are similar to those contained in SM-1 will be the same. The primary difference will be the general purpose laboratory (GPL) furnishings contained in SM-2 that are not part of the SM-1 configuration. The GPL furnishings are made up of the experiment storage provisions, mechanical and electrical equipment, and optical equipment. All of these itmes are of a general laboratory nature and involve commercially available equipment; therefore, the tests will be mostly concerned with interfacing utility fit and functional checks.

Station Module (SM-3)

Configuration. The laboratory/dining/atmosphere management station module (SM-3) is shown in Figure 2.2-11. SM-3 provides laboratory facilities for the physics and biomedical experiments. The zenith airlock is located at the laboratory end. The air revitalization equipment for volume 1 is below deck in this module, and the galley and dining functions are located above deck.

Some examples of commercial equipment installations of a biomedical nature utilized in the SM-3 laboratory is shown in Figure 2.2-12. The items shown are either existing or slightly modified commercially available equipment. SM-3 is the fifth module launched in the initial station buildup.

Systems Tests. The acceptance tests for SM-3 will be conducted at the launch site. The integrated tests will be similar to those conducted at the factory for SM-2 and will be performed on the MSV. The systems verification tests for the laboratory/dining/atmosphere management systems also will be essentially the same as those specified for SM-2. Table 2.2-6 summarizes these tests and shows the minor differences with those of SM-2.

Station Module (SM-4)

Configuration. The crew and control station module (SM-4) shown in Figure 2.2-13 is essentially a duplicate of SM-1 with regard to staterooms, hygiene facilities, and the control center. The medical and crew care function has been incorporated into this module.

SM-4 is the sixth module launched in the initial station buildup.

Systems Tests. The acceptance tests for SM-4 will be conducted at the launch site. The integrated tests will be similar to those conducted at the factory for SM-1 and will be performed on the MSV. The systems verification tests are essentially the same as those described for SM-1. Table 2.2-7 summarizes these tests and reflects the minor differences with those of SM-1.

2.2.1.4 Weight and Balance/Preparations for Move to VAB

The baseline determination of weight and balance of the individual modules will have been determined at the factory (except as discussed under Crew and Cargo Requirements, Section 4.0).

The power module is unique in the requirement for weight and balance, because it contains the high-pressure O_2 and N_2 tanks for repressurization of the MSS. As a result of safety considerations to personnel during handling, the tanks will not be loaded until the power module arrives at the pad in the shuttle orbiter cargo bay. The baseline weight and balance therefore will require correction utilizing known positions of the tanks and computed weights of gas as a function of gas pressure, temperature, and volume.

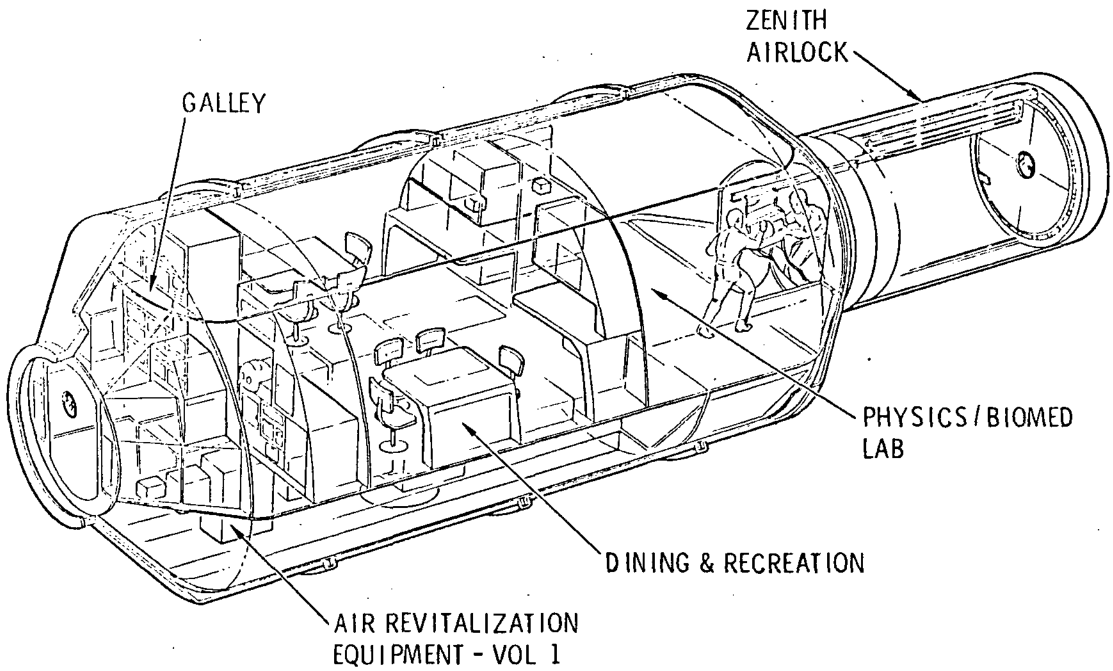


Figure 2.2-11. Laboratory/Environmental Control — Module 3

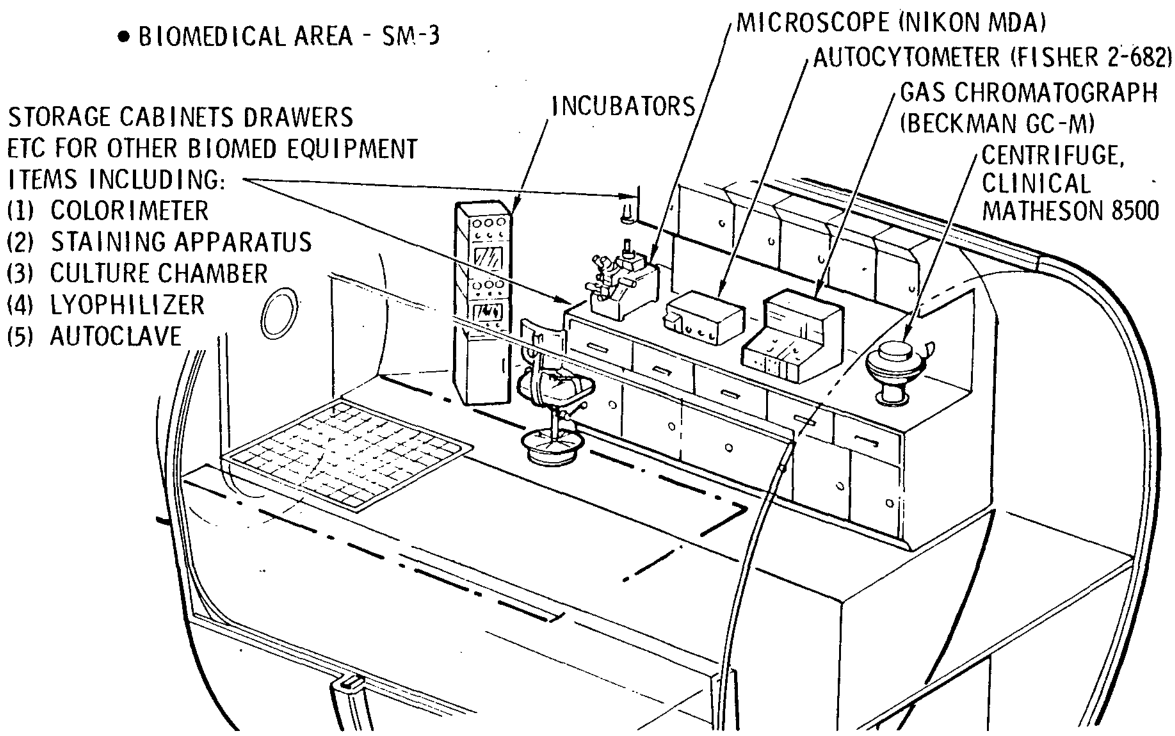


Figure 2.2-12. Examples of Commercial Equivalents

Table 2.2-6. Station Module (SM-3)

System	Test and Operational Requirement	Purpose and Rationale	Test and Operational Technique	Support Requirement	
				UTE/MSV	GSE
	Note: Station modules SM-2 and SM-3 are similar in construction and have essentially similar equipment configurations. The test requirements for SM-3 are therefore the same as those shown for SM-2, except for the following differences:				
ISS					
Command and control and monitoring					
Microfilm projector	Tests for SM-3 not required.	Equipment not installed in SM-3.			
Communication (internal)					
TV monitors	← Same as SM-1 and SM-4 →				
Crew Habitability					
Food management					
Utensil and food storage	← Same as SM-4 →				
Recreation/exercise/crew care					
Dining and recreation	Perform functional operation check of installed equipment. Conduct C^2F^2 with flight crew participation.	Verify readiness for launch. C^2F^2 required to familiarize crew with equipment storage locations and anomalies.	Utilize MSV. Flight crew participation required.	X	
Structural and Mechanical					
General purpose Laboratory furnishings					
Physics equipment	Verify operational interfaces with equipment such as power, lighting, etc.	Verify launch readiness	Utilize MSV.	X	

Table 2.2-7. Station Module (SM-4)

System	Test and Operational Requirement	Purpose and Rationale	Test and Operational Technique	Support Requirement	
				UTE/MSV	GSE
	Note: Station modules SM-1 and SM-4 are similar in construction and have essentially the same installed equipment configurations. The test requirements for SM-4 are therefore the same as shown for SM-1, except for the following differences:				
ECLSS					
Hygiene					
Shower	Tests for SM-4 not required	Equipment not installed in SM-4.			
Galley and labatory sink	Verify functional performance of sink including water supply system.	To ensure launch readiness and no shipment damage.	Perform tests using MSV.		
ISS					
Command and control and monitoring					
Commander's control console	Tests for SM-4 not required.	Equipment not installed in SM-4.			
Operational control console 2	(Same as SM-1 for operational control console 1)		(Same as SM-1)		
Data processing assembly					
Data analysis laboratory Photo processing Photo storage	Tests for SM-4 not required.	This capability is not included in SM-4			
Crew Habitability					
Food management					
Utensil and food storage	Perform crew compartment fit and functional (C^2F^2), crew evaluate general livability of staterooms and exercise area.	To familiarize crew with storage location and peculiarities.	Perform with SM-4 docked to MSV core module. Flight crew participation required.	X	
General					
Commander's stateroom Executive's stateroom Exercise area					
EPS					
Energy storage:					
Electrolysis unit	Tests for SM-4 not required.	Equipment not installed in SM-4.			

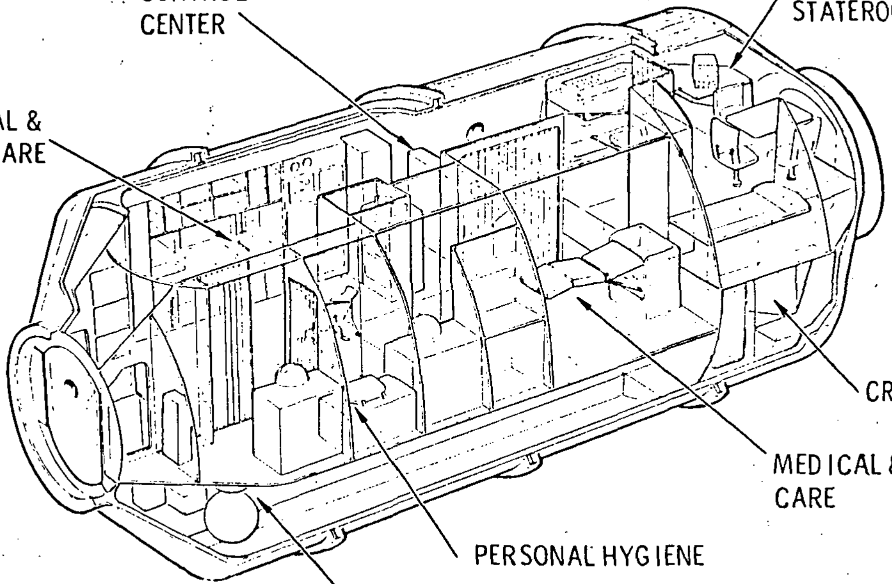


Figure 2.2-13. Control/Crew - Module 4

The remaining modules will not require weight and balance operations at the launch site unless significant configuration changes occur to a given module just prior to launch. In this event, the technique and equipment discussed for cargo module loading would be utilized.

Typically, the preparations for the move to the VAB from the MSOB for all of the modules will begin with tear-down of test setups. Clean rooms will be moved back and all openings will be covered with doors, access covers, hatches, etc. The appropriate modules will be demated from the MSV/UTE, weather-proofed, and loaded aboard the transporter. Weatherproof covers will be placed over modules while in transit to the VAB. Upon completion of these activities, the given module will be ready for the move to the VAB.

2.2.1.5 Move to VAB/Install in Shuttle Orbiter

With move preparations completed, the module transportation procedure to the VAB will be essentially the same for all of the modules. NASA security assistance will be necessary for traffic control during the trip to the VAB. A prime mover or tug will be connected to the module transporter in the MSOB at the east high bay door. The design of the transporter should consider the special floor loading restrictions in the east end of the MSOB high bay. The restrictions result from the tunnels connecting the altitude chambers with pumpdown equipment rooms along the south wall of the high bay.

The move to the VAB will require approximately 1 hour until arrival at the low bay for start of orbiter installation preparations.

The preparations will be concerned with installation of slings and lifting fixtures to the modules and verification that the trunnion attach points in both the module and orbiter are ready for module installation. Final closeout of all panels and openings, removal of weatherproofing material, and visual verification of the module berthing and docking interface with the shuttle adapter will be accomplished.

The module will be towed to the orbiter maintenance and checkout (M&C) area, shown in Figure 2.2-14, for installation in the orbiter. The 250-ton crane, already in existance in the VAB, will be utilized for loading operations.

Following completion of the module installation in the orbiter cargo bay, interface verification checks will be performed between the orbiter and module. The fit-check of the module with the orbiter adapter will have been assured by previous tests in the MSOB of an identical master tool representing the adapter interface.

Verification of proper connection and clearances of the shuttle manipulator with the module will be one of the last tasks performed prior to final closeout of the orbiter clam-shell cargo bay doors.

From this point in the module flow until it is placed in orbit, there will be no external access to the module, and module internal access must be gained from within the shuttle orbiter via the tunnel.

2.2.1.6 <u>Move to Pad/Load Consumables and High-Pressure Gases</u>

The baseline shuttle configuration used as a reference in preparing this report was previously given in Section 1.0. The assumed configuration uses the LUT and crawler transporter for moving the stacked shuttle and orbiter to the pad with this operation being the prime responsibility of the shuttle program. Critical functions required to be monitored aboard the module must be accomplished via the shuttle ISS during transit to the pad.

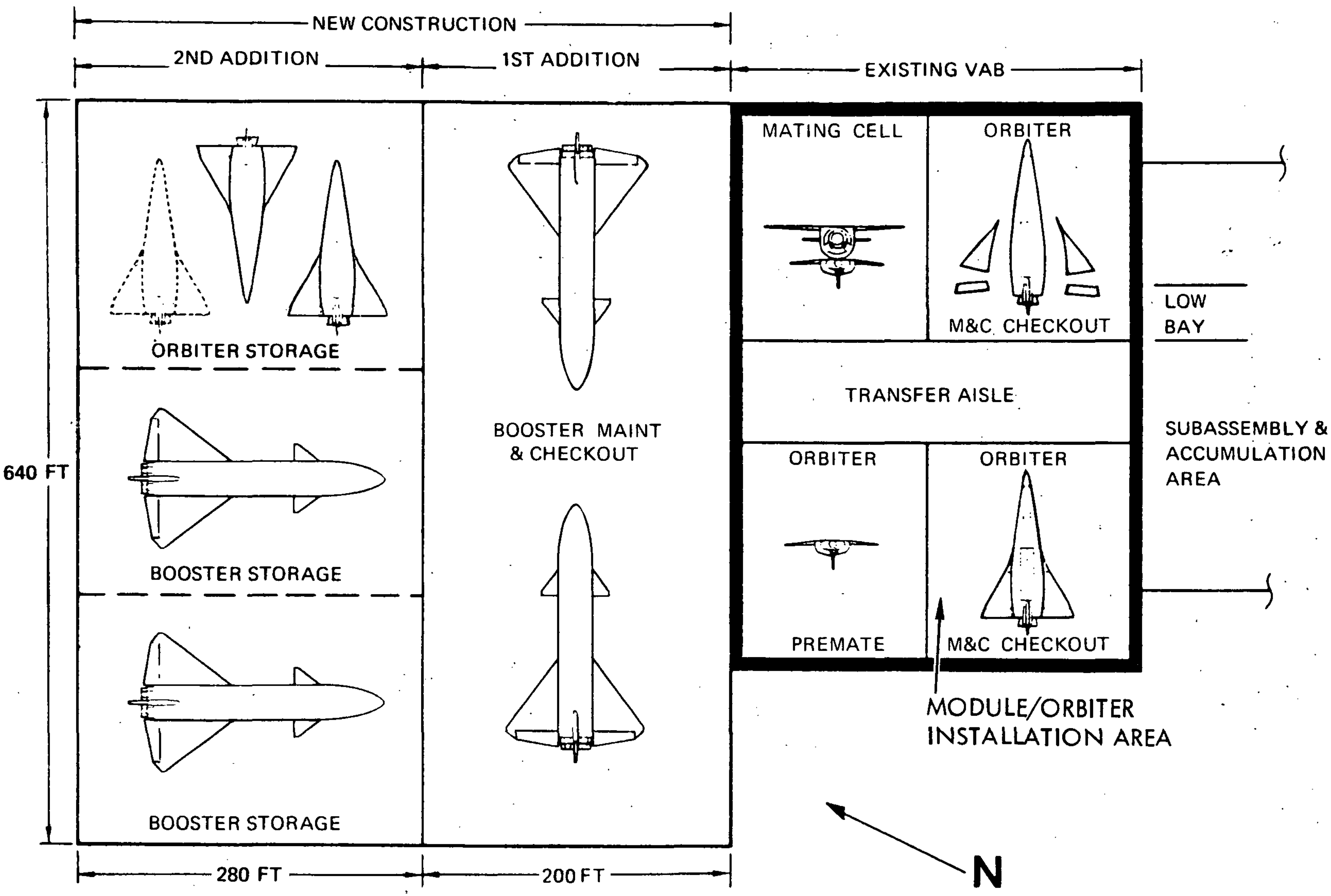


Figure 2.2-14. Module/Orbiter Installation

Operations required at the pad are minor in keeping with the philosophy of minimal access and testing of the modules after installation in the orbiter cargo bay. The most significant activities performed at the pad relate to loading of high-pressure gases and time-critical consumables. High-pressure O_2 and N_2 gases are housed in the power module for repressurization of the MSS in orbit. The loading of these gases was deferred until pad operations to reduce the exposure of personnel to the hazard of high-pressure gas containment. Loading operations will require a command control system like the system described in Section 4.0 for crew and cargo module loading. An umbilical or loading connection to the module(s) is required for the high-pressure gases, preferably as part of the shuttle configuration so that loading could be accomplished across the berthing and docking interface. This would alleviate the problems associated with differing module configurations, because loading would be across a common interface.

Consummables other than high-pressure gases are probably mainly food items requiring special handling, although specific details are lacking at this time. Requirements for potential ordnance and pyrotechnic hookups would be satisfied during pad operations.

2.2.2 GROWTH STATION

The buildup to the growth station is shown in Figure 2.2-15. The 12-man capability is achieved by the addition of a short core module with added fuel-cell and electrolysis equipment and two station modules (SM-5 and SM-6) with crew quarters and life support. The 7000-square-foot solar array of the initial station will be expended to a 10,000-square-foot array.

The dimensional characteristics of the growth station are indicated in Figure 2.2-16 along with the final positioning of the modules. The major equipment items comprising the added station modules (SM-5 and SM-6) are shown in Table 2.2-8; the major equipment items of the other station modules are repeated for references purposes.

The MSS master program schedule in Figure 1.2-18 shows the growth station elements and their development from fabrication through launch. The subsystems checkout and acceptance tests will be performed utilizing the mission support vehicle (MSV) described in Section 3.0 of this report.

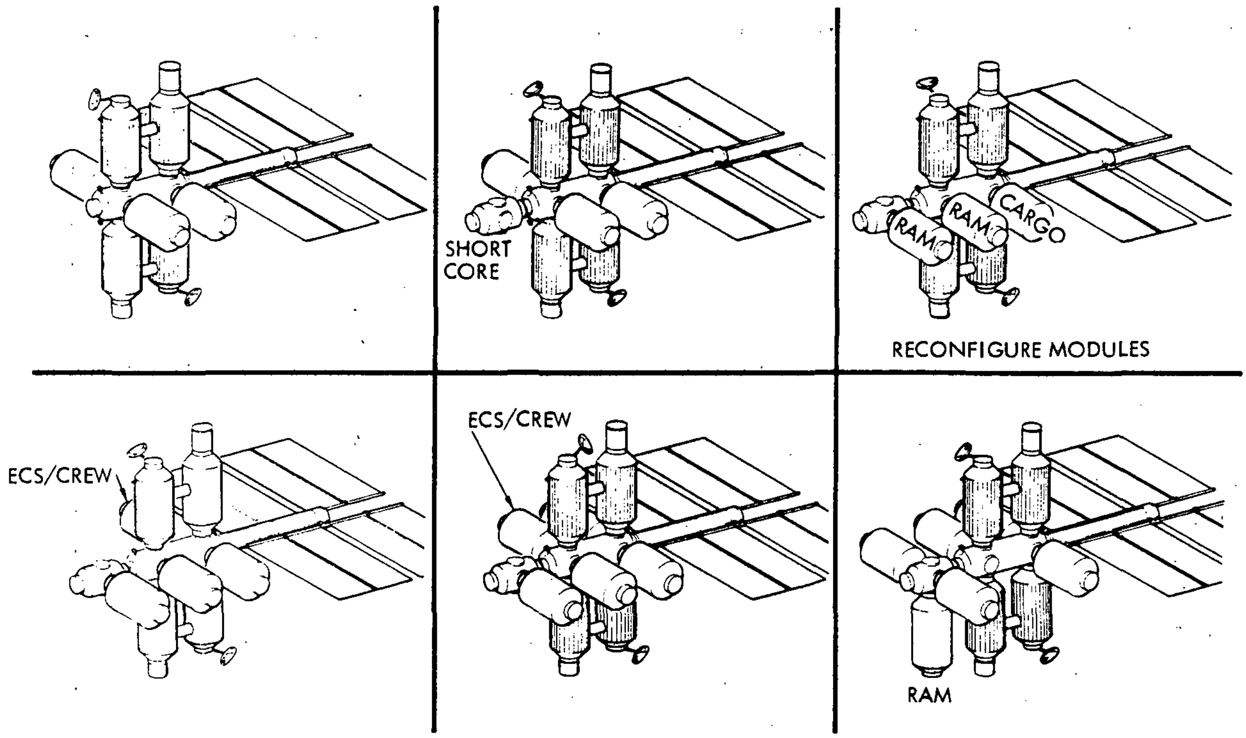


Figure 2.2-15. Buildup to Growth

Table 2.2-8. Subsystem Major Equipment Allocation
Growth Station

Equipment Item	Station Module					
	SM-1	SM-4	SM-3	SM-2	SM-5	SM-6
ECLSS						
Trace contaminates			X	X	X	X
Sink	X	X	X	X	X	X
Water storage	X	X			X	X
Potable water recovery	X	X			X	X
CO_2 management			X	X	X	X
Pressure control			X	X	X	X
Water electrolysis			X	X	X	X
Humidity control			X	X	X	X
Contamination control			X	X	X	X
Vapor compression			X	X	X	X

Table 2.2-8. Subsystem Major Equipment Allocation
Growth Station (Cont)

Equipment Item	Station Module					
	SM-1	SM-4	SM-3	SM-2	SM-5	SM-6
Water purity monitor	X	X			X	X
Dry john	X	X			X	X
Urinal	X	X			X	X
Shower		X			X	
Vacuum cleaner			X	X		
Pumpdown unit			X	X		
Local charcoal canisters	X	X	X		X	X
Sensible heat exchanger and fans	X	X	X	X	X	X
Trash processing			X	X		X
Temperature control unit	X	X	X	X	X	X
Radiators	X	X	X	X		
Coldplates	X	X	X	X		
Water loop plumbing	X	X	X	X	X	X
Resistance oven			X			
Reconstitution unit		X	X			
Refrigerator			X			
Freezer			X			
Microwave oven		X	X			
ISS						
Central processor	X	X				
Control console	X	X				
Commander's D/C console	X					
Microfilm viewer	X	X				
Parabolic antenna	X	X				
Remote terminal unit	X	X				
Audio recorder	X	X				
Remote processing units	X	X	X	X	X	X
Local monitor and alarm units	X	X	X	X	X	X
Audio-video unit	X	X	X	X	X	X
TV camera	X	X	X	X	X	X
TV monitor	X	X	X	X	X	X
Semidirectional antenna	X	X	X	X		

Table 2.2-8. Subsystem Major Equipment Allocation
Growth Station (Cont)

Equipment Item	Station Module					
	SM-1	SM-4	SM-3	SM-2	SM-5	SM-6
Crew Habitability						
Utensil/food storage		X	X			
PGA (2)	X	X				
PLSS (2)	X	X				
First aid kit	X	X	X	X	X	X
Fire control unit	X	X	X	X	X	X
Portable O_2 bottles and masks	X	X	X	X	X	X
EPS						
Electrolysis units	X					
Secondary bus	X	X	X	X	X	X
Interior lighting	X	X	X	X	X	X

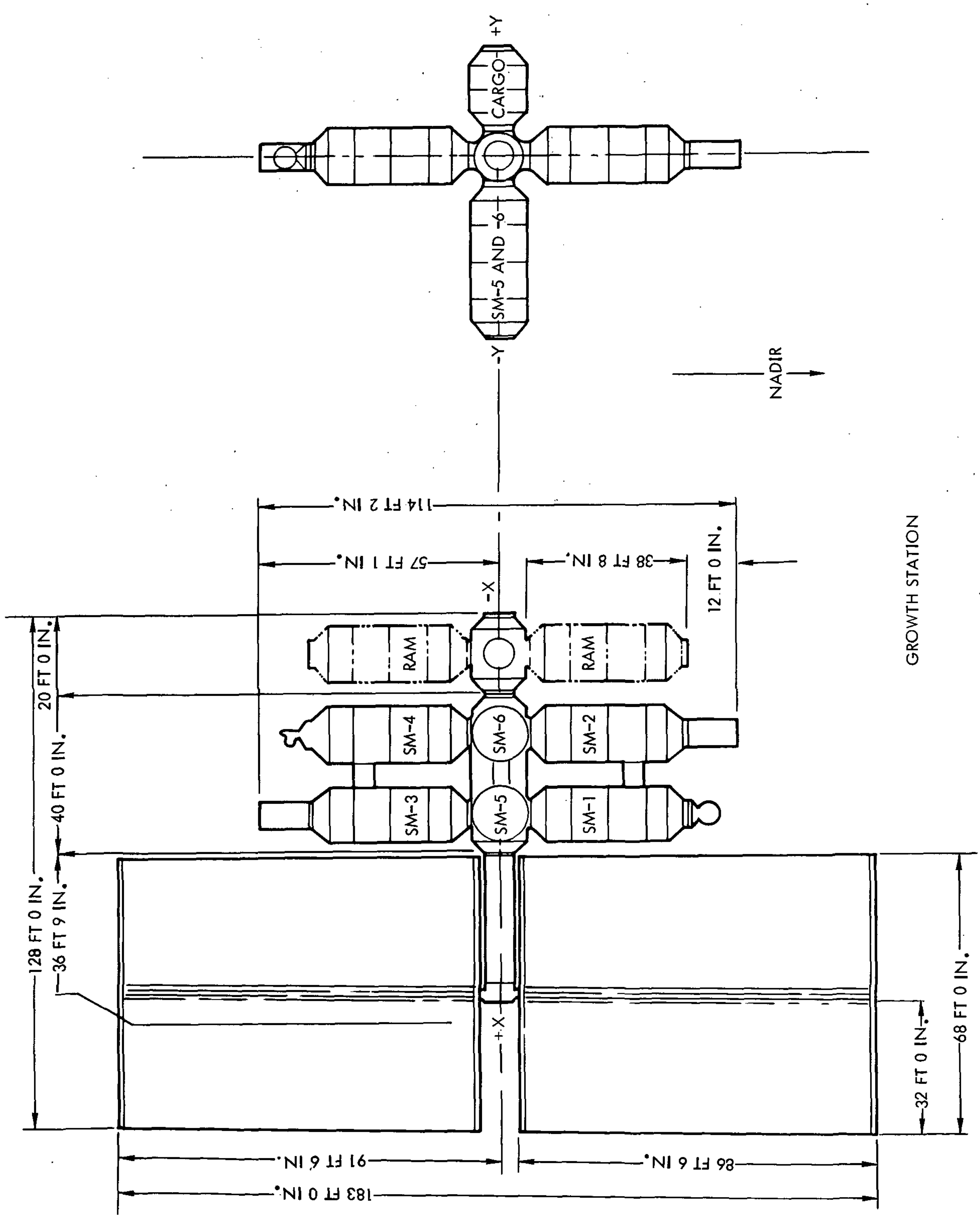


Figure 2.2-16. Growth Station

2.3 LAUNCH SITE PROGRAM SCHEDULE AND FLOW PLANS

The schedules and flow plans necessary to implement the launch site operational requirements for the initial and growth stations are contained in this section. The two phases of the program, initial and growth stations, each possess unique requirements.

The first phase is concerned with initial station buildup in which minimal testing will be accomplished at KSC predicted upon completion of acceptance testing for the first four modules at the factory.

Tests during this phase will be confined mostly to system end-to-end verification at the launch site. The mission support vehicle (MSV), described in Section 3.0, and UTE will be the main tool for accomplishing the verification testing.

The second phase relates to the growth station and modules or MSS elements returned from orbit for repair or modification. Resupply missions and experiment module launches (RAM's) are included in this phase. Testing during this period will be oriented more to systems integration, post-modification and repair checkout, and acceptance tests utilizing the MSV. It is anticipated that factory operations pertinent to the MSS will be at a low level of activity with most factory-mode operations occurring at the launch site (KSC).

The launch site schedules and flow plans contained herein show the relative phasing of the previously mentioned schedule periods.

2.3.1 LAUNCH SITE MASTER SCHEDULE/GSE AND FACILITY ACTIVATION

The key events occurring at the launch site during the prelaunch and launch operations are shown in the master schedule, Figure 2.3-1. The schedule indicates the general activity milestones, completion of facility and GSE activation and checkout, and the initial and growth station launch schedule. The utilization of the MSV for the initial station launches is mostly concerned with acceptance tests of SM-3, SM-4, and the cargo flight modules.

The MSV will support orbital operations of the initial station and acceptance tests of the growth elements: solar array (10,000 ft), short core module, SM-5, and SM-6 as shown in Figure 2.3-1.

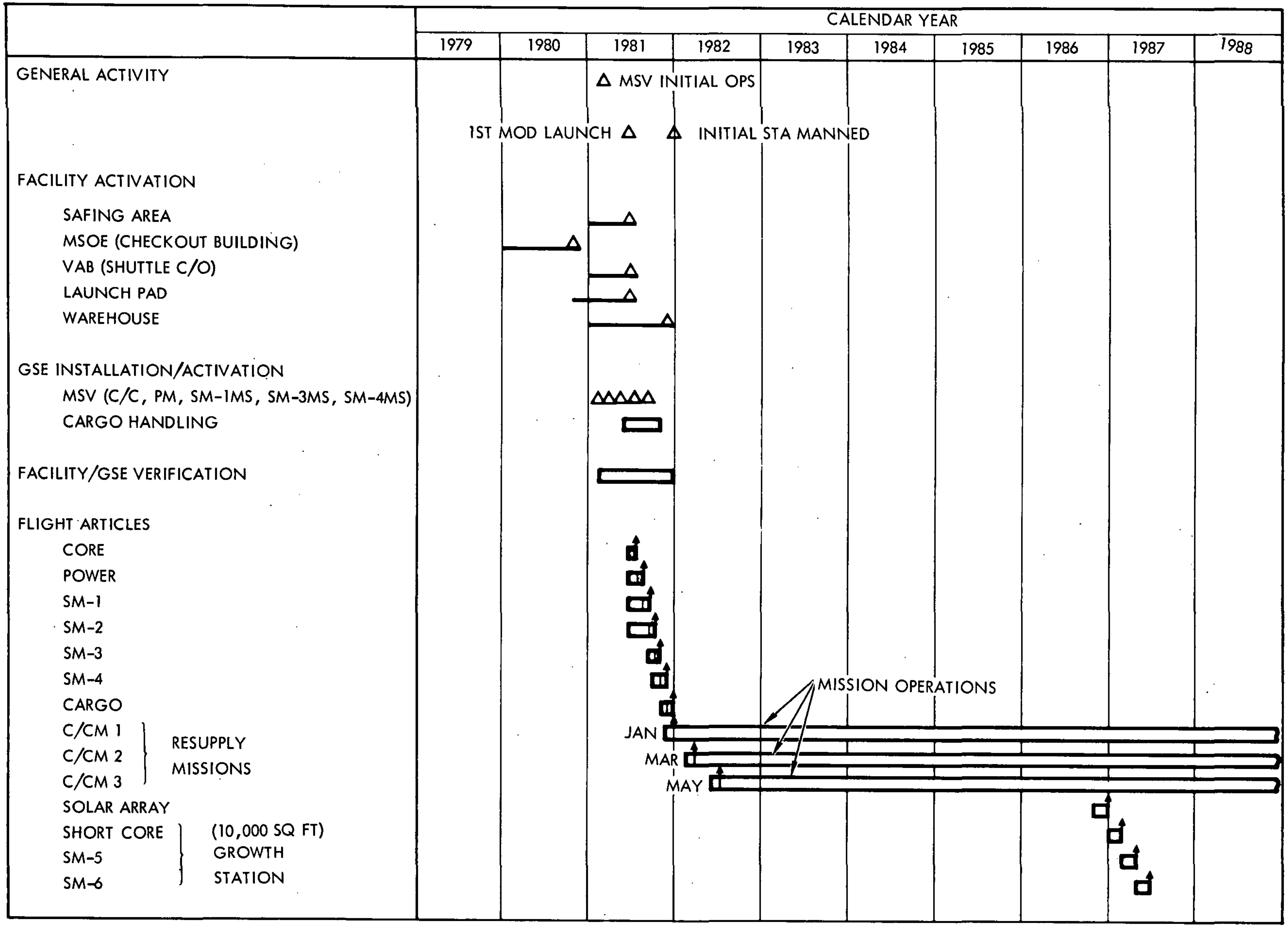


Figure 2.3-1. Launch Site Master Schedule/GSE and Facility Activation

The indicated milestones are those required to support the MSS program and do not necessarily reflect the requirements imposed by other elements of the shuttle program.

2.3.2 MSS LAUNCH PREPARATION FLOW PLANS

The modular space station flow plans of this section of the report present the time-phasing of the tests specified in paragraph 2.2.1.3 for each of the modules of the initial station. The flow plans are based on a two-shift (16-hour) work schedules and do not include weekend days for the module operations; however, shuttle operations for the final 3 days prior to launch are based on three shifts and include weekends if necessary. Each of the flow plans, therefore, reflects calendar days, because each contains an appropriate allowance for weekend days.

The sequential procedure for constructing the flows began with the determination of test and operations requirements, followed by the establishment of test techniques. Finally, an individual assessment of the time to complete each test was made and whether or not it could be performed in parallel, combination, or serially with other tests.

The initial station is comprised of seven basic modules:

Core
Power
Station module SM-1
Station module SM-2
Station module SM-3
Station module SM-4
Cargo module

Of these, only the first six will be discussed in this section of the report, because Section 4.0 is devoted entirely to cargo requirements while the RAM configurations are variable in nature, depending upon the experiment configurations. In addition, it is important to point out the SM-1 differs only slightly from SM-4 as does the SM-2 from SM-3. Therefore, the launch preparation flows for SM-3 and SM-4 are not included herein. The acceptance tests for SM-3 and SM-4 would be similar to the factory tests for SM-1 and SM-2 and are not discussed in this document.

2.3.2.1 Core Module

Figure 2.3-2 depicts the launch preparation flow for the core module, which, as indicated, will require approximately 20 calendar days after delivery to prepare the module for launch. The usage of GSE will be minimized with emphasis on system verification from the on-board ISS systems

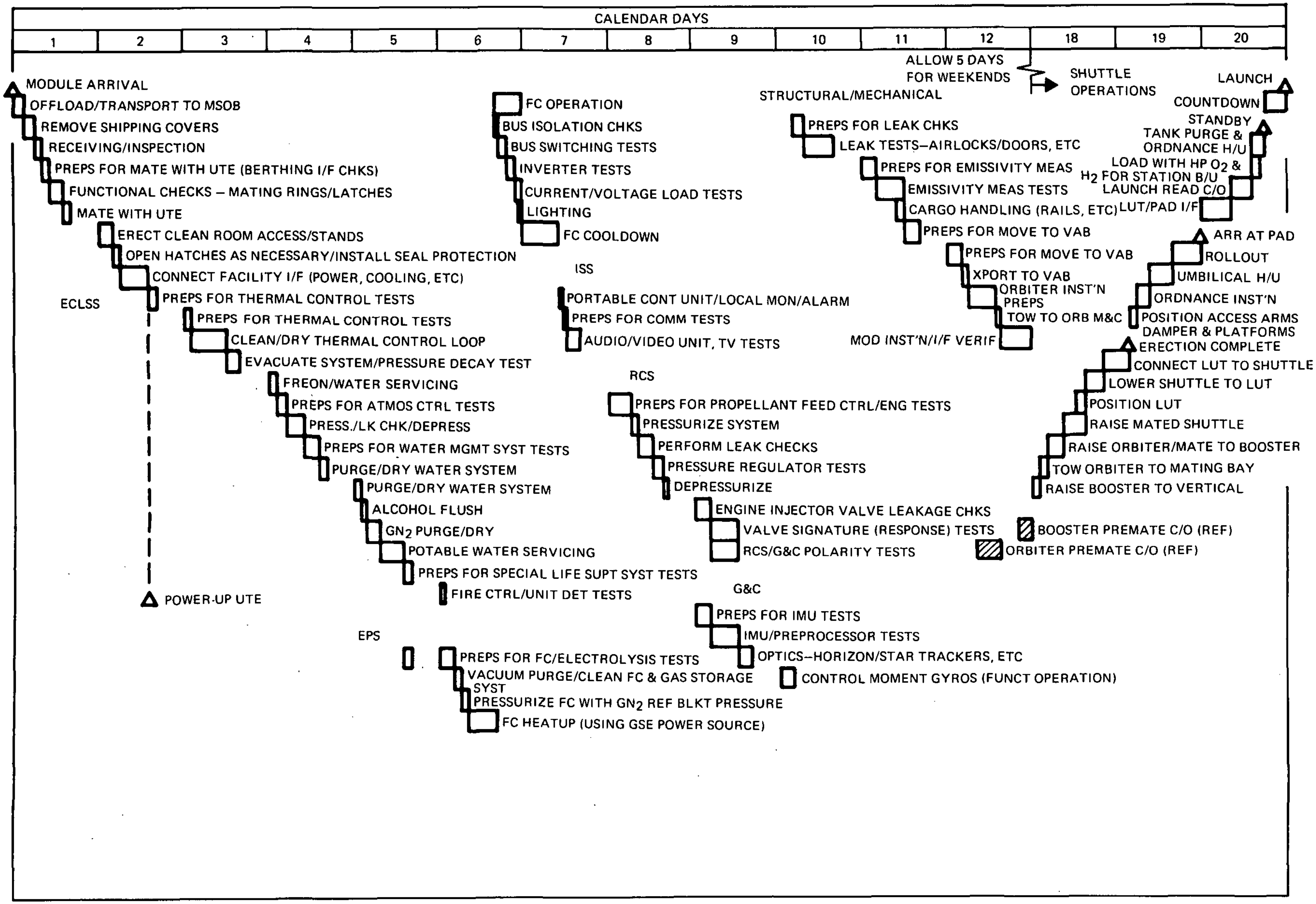


Figure 2.3-2. Core Module KSC Flow

simulations contained in the UTE. The flow of the core module does not reflect scheduled time for weight and balance operations, because it is assumed this function will have been performed at the factory prior to delivery.

2.3.2.2 Power Module

Figure 2.3-3 presents the launch prepration flow for the power module, which, as shown, requires the shortest checkout and verification time than any of the other modules. The 11-day period shown are calendar days, which means that just 9 workdays are required for checkout of the power module. Delivery of the power module from the factory precedes the required final delivery date at KSC by approximately 2 months. This early delivery from the factory results from the integrated test simultaneous completion of the flight core module, power module, and station modules SM-1 and SM-2. Thus, all four of these modules are delivered earlier than their required minimal checkout dates.

Therefore, it will be necessary to store the power module in the low bay portion of the MSOB until approximately 2 weeks (11 days) prior to launch.

The flow, as shown in the figure, assumes that verification tests will commence 1 to 2 days after delivery. As a result of the early delivery, the removal of the shipping covers shown in the flow can be deferred until about 11 days prior to launch, and the power module can be moved directly to the MSOB low bay for temporary storage following the off-loading operation shown in the flow.

The power module and core module are unique from the point of view that they are the only modules that require the loading of high-pressure gases. Loading of high-pressure gases in the MSOB is not permitted because of safety considerations. Tests of the 3000-psi gaseous storage system can be performed at 25-percent design burst for the high-pressure tanks in the MSOB, but the loading operation must be postponed to the final orbiter/booster loading operations at the pad. In this respect, the power module and core module are the only modules that influence the shuttle countdown operation in the final 3 days prior to launch. This loading operation produces a direct interface requirement with the shuttle in that a means must be provided to load high-pressure gases at the pad with the modules closed out in the orbiter cargo bay. The weight and balance variation on the on-loaded gases can be a computed value correcting the baseline value established by the factory weight and balance operation.

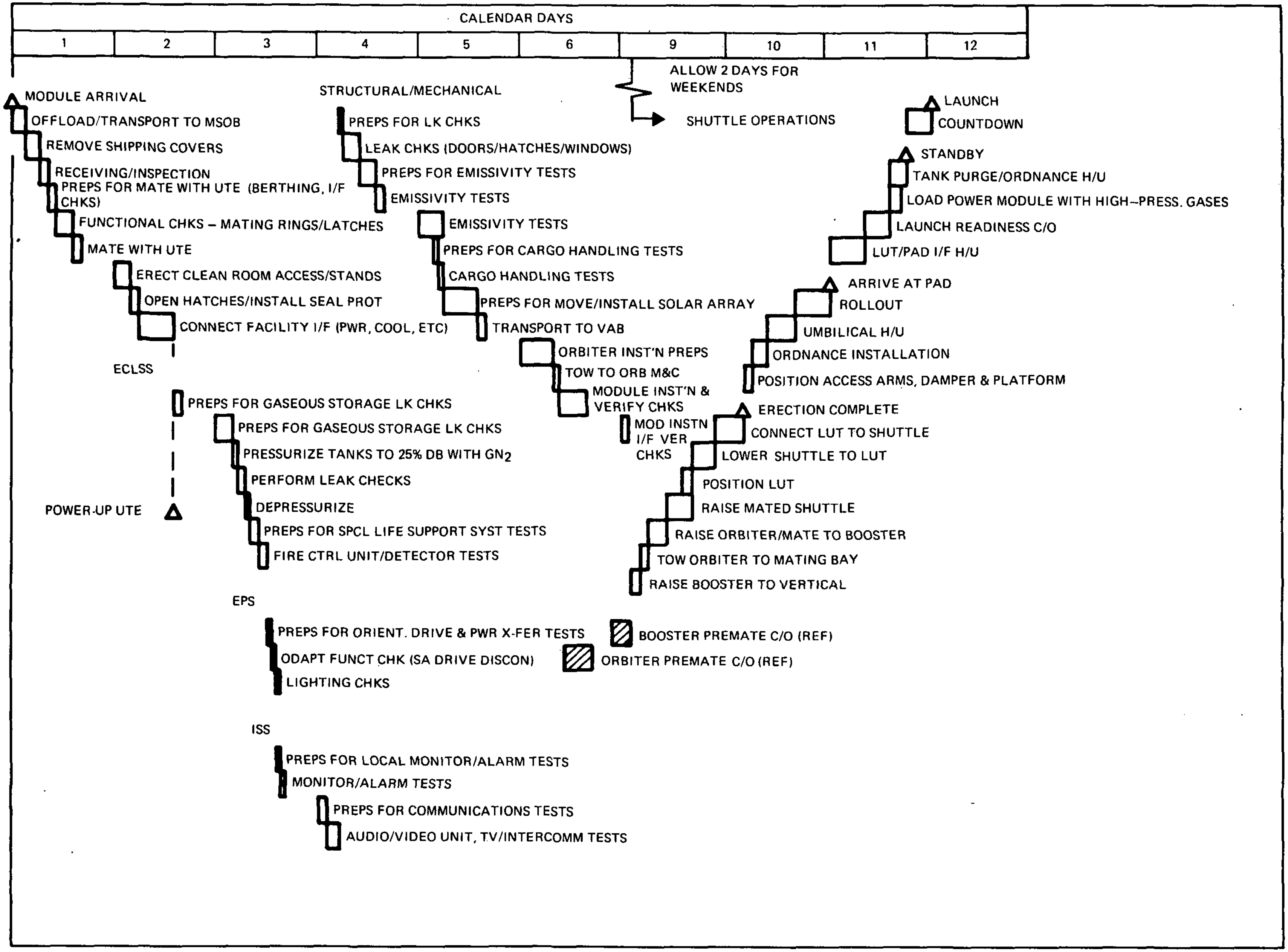


Figure 2.3-3. Power Module KSC Flow

2.3.2.3 Station Module (SM-1)

Figure 2.3-4 shows the launch preparation flow for the crew and control station module (SM-1). As indicated, the checkout and verification tests can be accomplished in about 14 actual workdays, or 19 calendar days, including the 3 days required for launch readiness and countdown of the shuttle. The delivery of SM-1 from the factory precedes the required final delivery date at KSC by about 2-1/2 months for the reasons explained in the previous discussion of the power module. As a result of this early delivery, it will be necessary to temporarily store SM-1 in the low bay of the MSOB until approximately 3 weeks (19 to 20 days) prior to launch.

As in the case of the power module, the flow for SM-1 assumes the verification tests will begin 1 to 2 days after delivery; consequently, the removal of the shipping covers can be deferred until 19 to 20 days prior to launch, and SM-1 can be moved directly to the MSOB low bay for temporary storage following the off-loading operation of the module.

The ISS verification tests are more comprehensive for SM-1 (and SM-4), because the bulk of this equipment is housed in these modules. ECLSS tests also are more stringent for these modules because of the high percentage of habitability by the flight crews during orbital operations.

2.3.2.4 Station Module (SM-2)

Figure 2.3-5 reflects the flow for launch preparation of the laboratory/ atmosphere management station module (SM-2). The figure indicates that the launch flow for SM-2 can be accomplished in 19 calendar days or about 14 actual work days, including the 3-day shuttle launch operation activity. The delivery procedure and rationale for SM-2 is similar to the power module and SM-1 discussed previously and differs only in that the temporary storage period at KSC will be about 3 months. The early delivery will precipitate the same pattern of events (i.e., SM-2 will be moved directly to the low bay of the MSOB for storage until approximately 3 weeks prior to the start of the launch preparation operation).

The high percentage of crew occupancy of SM-2 creates the need for more emphasis on the ECLSS than other systems. The flow shows rather minor checkout of the laboratory and installed mechanical and electrical and optical equipment based on an assumption that such equipment will be largely commercial with established records of reliability.

2.3.2.5 Crew and Cargo Module

The crew and cargo module flows are presented in Section 4.0 as part of the cargo module operations analysis.

2.3.2.6 Research Applications Modules (RAM)

The RAM flows have not been prepared, because their configuration and subsequent checkout and system verification are a part of the experiment programs, which is not directly related to the requirements of this study.

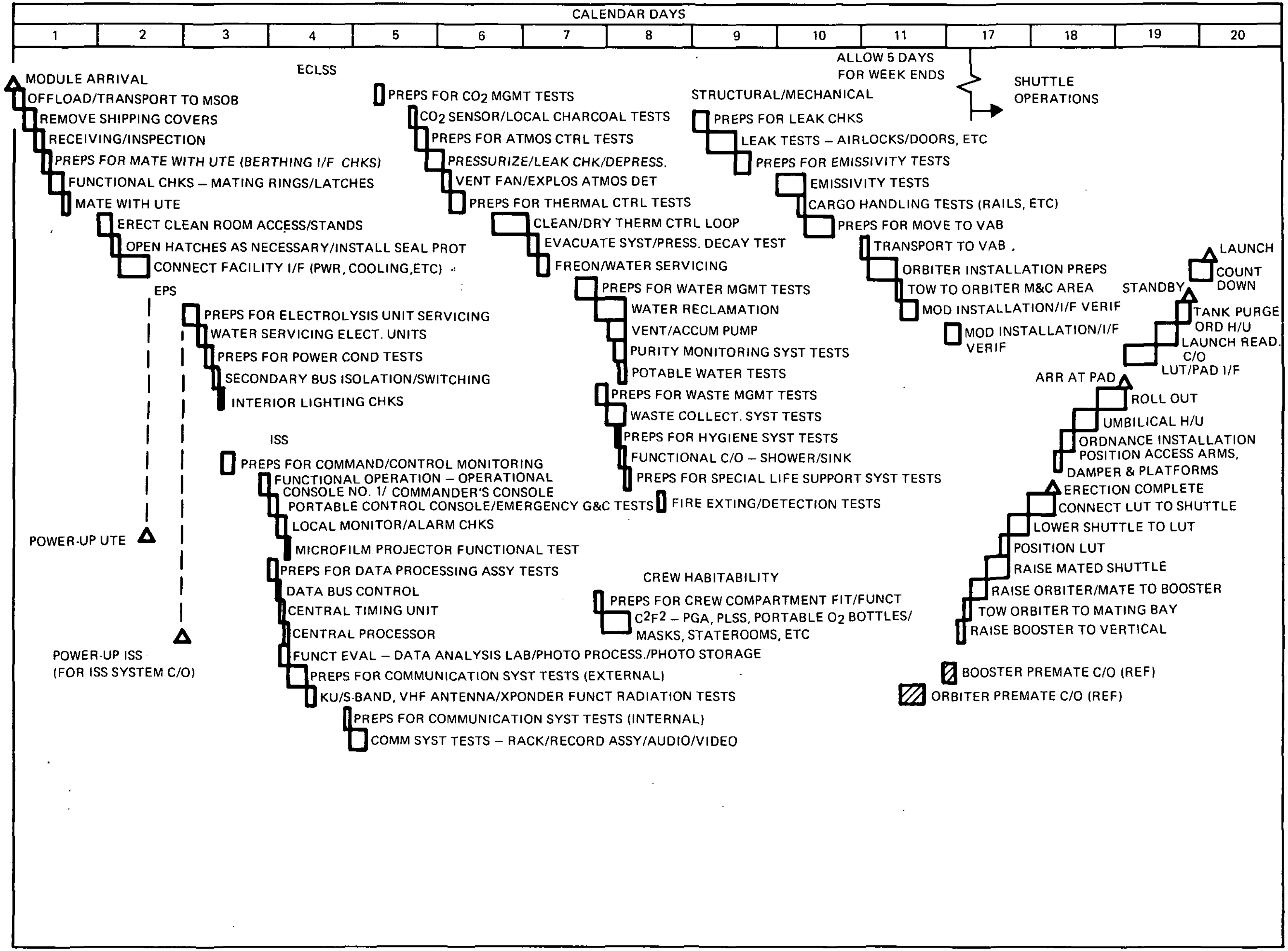


Figure 2.3-4. Station Module (SM-1) KSC Flow

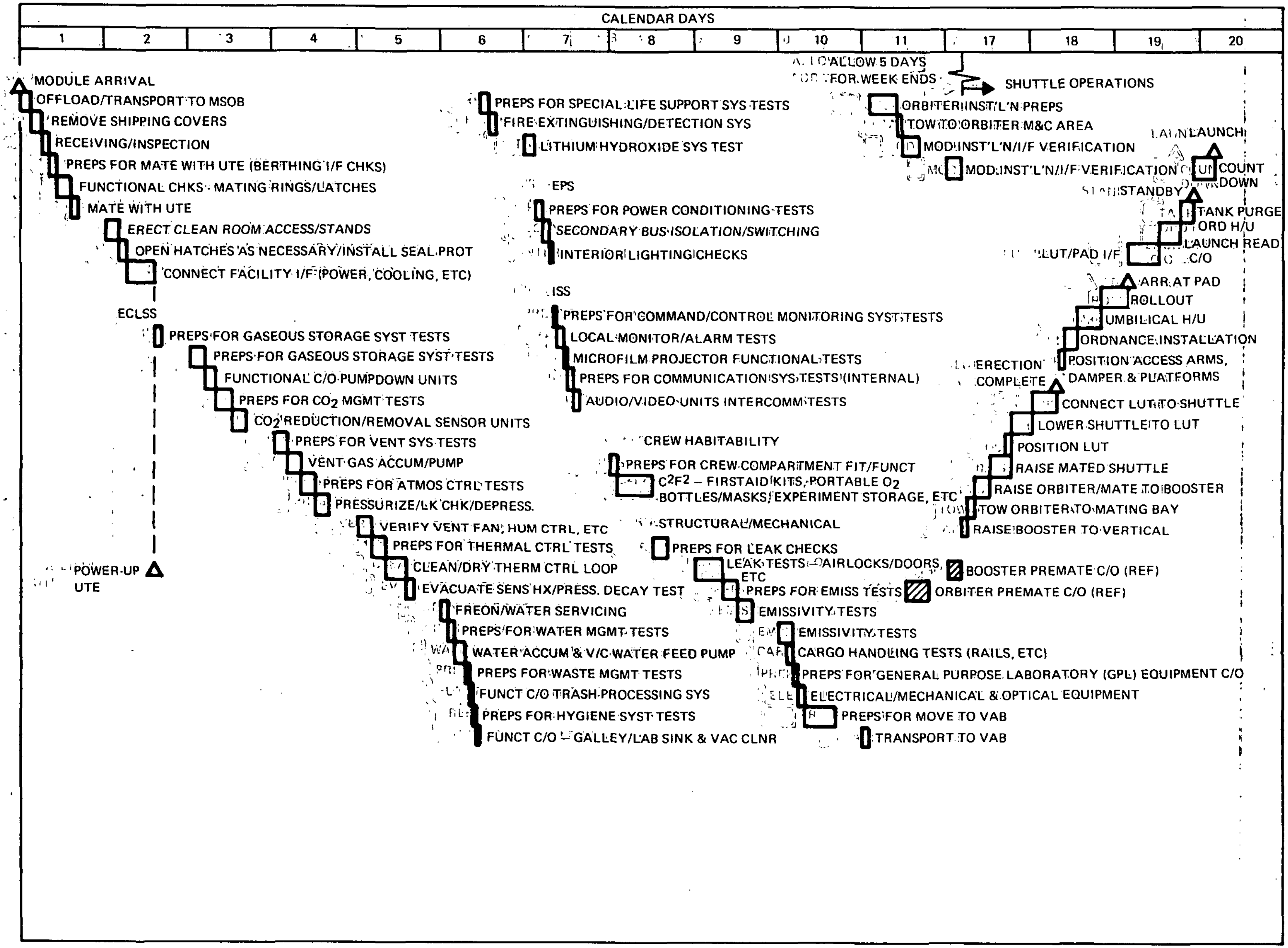


Figure 2.3-5. Station Module (SM-2) KSC Flow

2.4 GSE AND FACILITIES REQUIREMENTS SUMMARY

During this study, test requirements were defined and module handling operations were identified. For convenience, the GSE and facilities necessary to accomplish the prelaunch and launch operations are summarized in this section. Tables 2.4-1 and 2.4-2 summarize the GSE and facility requirements, respectively. The tables enumerate the type of equipment or facility, the modules of the initial and growth station for which it is required, the facility area at KSC where the equipment is required, identify candidate existing equipment, and specify new equipment.

It should be noted that candidate equipment may be obsolete or may not be economical to maintain until required for use on the space station program. It has been identified as candidate equipment for two reasons: the design satisfies the requirements; and those familiar with Apollo program operations will be able to relate to the intended utilization and planned activity.

Table 2.4-1. MSS GSE Requirements/Use Summary

NOMENCLATURE	INITIAL ← → GROWTH																LOCATION					EQUIPMENT	
	CARGO 1	CARGO 2	CARGO 3	CARGO 4	POWER	CORE	STATION 1	STATION 2	STATION 3	STATION 4	STATION 5	STATION 6	SOLAR ARRAY	RAM	SHORT CORE	SAFE AREA	MSOB	WARE-HOUSE	VAB	PAD	NEW	EXISTING GSE CANDIDATE
FREON SERVICING UNIT	●	●	●	●		●											●				●	
WATER SERVICING UNIT	●	●	●	●		●											●				●	
LEAK DETECTION UNIT	●	●	●	●		●										●	●				●	
VACUUM PUMP	●	●	●	●		●											●				●	
TRACE CONTAMINATE DETECTOR						●											●				●	
INTERFACE, ADAPTER-MODULE/GSE	●	●	●	●	●	●	●	●	●	●	●	●		● ●	●		●				●	
WATER TRANSFER UNIT						●	●	●		●							●					S14-119
PNEUMATIC CONSOLE						●											●					C14-075
INSTRUMENT RECORDER						●											●					C34-664
ELECTRICAL LOAD BANK	●	●	●	●		●											●					A14-074
LEAK DETECTION UNIT	●	●	●	●		●	●	●	●	●						●	●			●		S34-160
HELIUM MASS SPECTROMETER						●			●								●					S34-160
EMISSIVITY DEVICE	●	●	●	●	●	●	●	●	●	●	●	●	●	● ●	●		●					C14-410
PNEUMATIC CONSOLE	●	●	●	●	●															●	●	
FREON CIRCULATION UNIT							●	●		●							●					S14-121
PGA O_2 SUIT LOOP C/O UNIT							●	●	●	●	●	●					●					A14-033
TOXIC VAPOR DISPOSAL UNIT							●	●		●						●	●					S14-060
HATCH SEAL PROTECTORS	●	●	●	●	●	●	●	●	●	●	●	●		● ●	●		●	●	●		●	
POWER SUPPLIES	●	●	●	●	●	●	●	●	●	●	●	●		● ●	●		●	●	●	●	●	
HYDROMETER	●	●	●	●		●											●				●	
LIGHT METER	●	●	●	●	●	●	●	●	●	●	●	●		● ●	●		●				●	
PRIME MOVER	●	●	●	●	●	●	●	●	●	●	●	●	●	● ●	●		●	●	●			M-24
HANDLING SET	●	●	●	●			●	●	●	●	●	●						●	●		●	
HANDLING SET					●								●	● ●			●	●	●		●	
HANDLING SET						●									●		●	●	●		●	
TRANSPORTER - HORIZONTAL	●	●	●	●	●	●	●	●	●	●	●	●	●	● ●	●		●		●		●	
TRANSPORTER - VERTICAL	●	●	●	●														●				H14-173,8
LOAD CELLS	●	●	●	●														●				H14-177
VERTICAL WORKSTAND	●	●	●	●														●				H14-124
CARGO LOADING SET	●	●	●	●														●				A7-35
DC DIGITAL INDICATOR	●	●	●	●														●				A14-154-0001

Table 2.4-2. MSS Facility Requirements Summary

NOMENCLATURE	INITIAL ← → GROWTH															LOCATION				
	CARGO				POWER	CORE	STATION						SOLAR ARRAY	RAM	SHORT CORE	SAFE AREA	MSOB	WARE-HOUSE	VAB	PAD
	1	2	3	4			1	2	3	4	5	6								
NITROGEN SOURCE AND REGULATION	●	●	●	●	●	●									●		●			●
OXYGEN SOURCE AND REGULATION	●	●	●	●	●	●									●		●			●
HYDROGEN SOURCE AND REGULATION	●	●	●	●	●	●									●		●			●
HELIUM SOURCE AND REGULATION	●	●	●	●													●			●
FLUIDS DISTRIBUTION SYSTEM	●	●	●	●	●	●									●	●	●			●
HAZARDOUS GAS VENT SYSTEM	●	●	●	●	●	●		●	●		●	●			●	●	●			●
COMMAND AND CONTROL SYSTEM	●	●	●	●	●	●	●	●	●	●	●	●		● ●	●		●		●	●
ELECTRICAL POWER	●	●	●	●	●	●	●	●	●	●	●	●	●	● ●	●	●	●	●	●	●
OVERHEAD CRANES - 12 TON MIN	●	●	●	●	●	●	●	●	●	●	●	●	●	● ●	●		●	●	●	
FOOD STORAGE - REFRIGERATION	●	●	●	●														●		

3.0 MISSION SUPPORT VEHICLE OPERATIONS ANALYSIS

A mission support vehicle (MSV) will be developed to provide continuing ground support to the orbiting MSS in the form of a test tool capable of simulating MSS functions and interfaces. This vehicle will be used to support the development and to verify the interfaces of newly fabricated or modified MSS hardware and software. The MSV also will be used for timeline definitions and crew and passenger MSS familiarization.

Configuration and quality control systems will be applied to the MSV rigorously in order to ensure the highest level of confidence in its use as an interface and functional verification tool.

The MSV will consist of five modules: a core module (CM-2-MS), the control center station modules (SM-1-MS and SM-2-MS), a crew-quarter module (SM-3-MS), and a power boom. These modules shall be installed and docked directly as they would be in flight configuration.

3.1 MSV CONFIGURATION

The systems that will comprise the MSV will be built from qualified hardware identical to that utilized in the orbiting MSS and described in Section 2.1. In a few instances, adaptations to these systems will be required for practical consideration associated with MSV operation in an earth-bound environment. These adaptations are discussed in Tables 3.1-1 through 3.1-7.

Table 3.1-1. Environmental Control and Life Support System (ECLSS)
(Description: Reference Paragraph 2.1.1)

Subsystem	MSV Implementation Characteristics
Gaseous storage O_2 supply N_2 supply H_2 supply Repressurization Pumpdown	Bottles will be installed to provide spatial references but will not normally be used as storage units. The distribution system, including valves, accumulators, lines, etc., will be connected to external gas sources when required for subsystem verification. Controls and monitors will be active to provide the proper ISS loads and interfaces.

Table 3.1-1. Environmental Control and Life Support System (ECLSS) (Cont)

Subsystem	MSV Implementation Characteristics
CO_2 management CO_2 removal CO_2 reduction H_2O electrolysis	The equipment will be installed in the MSS and all its functional interfaces with the ISS will be active. Normal operations will not depend upon the on-board CO_2 management subsystem or CO_2 removal except during functional verification of this system.
Atmospheric control Circulation Temperature control Humidity control Pressure	This subsystem will be active and will be used for atmospheric control within the MSV. It will be supplemented by equipment in the white room at the controlled entrance to the vehicle.
Thermal control Internal coolant loop Heat rejection loop Passive temperature control Buildup and emergency	The MSV will have the same systems as does the orbiting MSS, except that the radiator loops will be connected to external cooling units capable of simulating space cooling and heating cycles.
Water management Water reclamation Water storage Purity control Waste Management Fecal collection Urine collection Trash processing Hygiene Full body washing Part body washing Housekeeping Special life support Fire control IVA support PLSS support	These systems will be installed or simulated in the MSV but will be activated only to the degree necessary to properly load the ISS.

Table 3.1-2. Electrical Power System (EPS)
(Description: Reference Paragraph 2.1.2)

Subsystem	MSV Implementation Characteristics
Primary power generation Solar array Orientation drive and power transfer (ODAPT)	The solar arrays will not be installed on the MSV; primary power will be supplied by GSE through the solar array connections. The GSE shall be capable of duplicating solar array power output characteristics. ODAPT hardware will be installed and will be capable of being operated to simulate loads on the power bus and ISS.
Secondary power generation Fuel cells Heat rejection Storage tanks	Fuel cells will be installed in the MSV, but normal backup, secondary power will be provided by GSE connected to the secondary power feeders. Usage and control of this secondary power source shall duplicate the behavior of the fuel cells at all interfaces. The electrolysis units and the fuel cells will be operable and will be activated when required to verify associated hardware and software.
Energy storage Electrolysis Fuel cells Storage tanks	Storage tanks will be installed but will be provided with lines to external sources where fluids and gases will be actually stored during normal operations. Heat rejection will be provided through the ECLSS ground cooling units.
Power conditioning Inverter Autotransformer Rectifier-filter Regulators	Power conditioning, distribution and control wiring, and the MSV lighting will be in flight configuration. This will require the ground power sources to simulate accurately the characteristics of the solar arrays, fuel cells, and energy storage devices.

Table 3.1-2. Electrical Power System (EPS) (Cont)

Subsystem	MSV Implementation Characteristics
Distribution and control wiring Feeders EPS controls Wiring Contractors, circuit breakers Buses Lighting Internal External	

Table 3.1-3. Guidance and Control (G&C)
(Description: Reference Paragraph 2.1.3)

Subsystem	MSV Implementation Characteristics
Inertial reference assembly Strapdown IMU IMU preprocessor Optical reference assembly Horizon tracker Star tracker Telescope/sextant Optical reference preprocessor Alignment links Moment exchange assembly Control moment gyro GMG preprocessor RCS electronics assembly Jet driver electronics RCS preprocessor	The G&C system in the MSV will consist of flight-type equipment with special provisions made for simulating external simulii. For example, dummy targets will be provided for the optical reference assembly.

Table 3.1-4. Reaction Control System (RCS)
(Description: Reference Paragraph 2.1.1)

Subsystem	MSV Implementation Characteristics
Propellant accumulator O_2 accumulator H_2 accumulator	A complete RCS system will be installed in the MSV. Gases will be supplied from external sources when required for specific tests.
Propellant feed control Valves Regulators	Propellant feed control valves, regulators, engines, and other associated hardware will be installed and will be operable to duplicate all mechanical, electrical, and control interactions.
Engine Engines Mounts	External ducting shall be provided at the engines to flow gases expelled during firing sequences into external storage tanks.

Table 3.1-5. Information Subsystem (ISS)
(Description: Reference Paragraph 2.1.5)

Subsystem	MSV Implementation Characteristics
Data processing Data bus control Central timing Central processor RACU Buildup data processor	MSV shall have the same data processing capbility as does the orbiting MSS with the following exceptions: (1) A buildup data processor will not be included (2) A full complement of RACU's will be included, but in some cases, as in the solar array, the RACU will be connected to a special simulator or to a piece of GSE substituting for the flight hardware.

Table 3.1-5. Information Subsystem (ISS) (Cont)

Subsystem	MSV Implementation Characteristics
Command and control monitoring Commander's control console Operational control console Emergency G&C control Portable control unit Local monitor alarm Microfilm projector	A full complement of command control and monitoring capability will be included in the MSV. In addition, monitoring capability shall be provided external to the MSV to allow for multiple observers to monitor the performance of given tests. This capability will be provided through the external communications subsystem.
External communications K-band antenna K-band antenna - mounted electronics K-band nonintegrated electronics S-band antenna S-band transponder VHF antenna VHF transponder SM K-band antenna extension	The MSV will include all the external communications equipment, with special providions made for operating closed loop both through antenna hats or through hardwires. These provisions are required for checkout of the external communications system itself and to provide additional MSV system monitoring capability on the ground.
Internal communications Communications rack Recording units Audio video units Hardwire intercom TV cameras color TV cameras black and white TV monitors color	A full complement of internal communications hardware will be installed in each of the MSV modules. In addition, the intercoms will be connected to the off-board operaational intercom system. Off-board TV monitors also shall be provided.
Software Computer programs Microfilm	The same software as that used in the orbiting MSS shall be utilized.

Table 3.1-6. Structural and Mechanical Subsystems

Subsystem	MSV Implementation Characteristics
Primary structure Secondary structure Environmental shield Berthing General purpose laboratory furnishings	The structural and mechanical systems for the core module, power module, SM-1-MS, and SM-4-MS will duplicate the corresponding systems in the flight articles. The SM-3-MS, however, will be a composite of SM-2 and SM-3. For this reason, secondary structures and furnishings will not be exact duplicates of either SM-2 or SM-3. Instead, they will be representative of these two modules with primary emphasis placed on maintaining the functional interfaces as intact as possible.

Table 3.1-7. Crew Habitability Subsystem

Subsystem	MSV Implementation Characteristics
Personnel equipment General emergency equipment Furnishings Recreation, exercise and crew care Food management Crew	The flight article configuration of this subsystem will be duplicated in the MSV within the bounds of practicality and constraints resulting from the unique configuration of the SM-3-MS. For example, food will not be stored in the MSV but emergency equipment will.

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3.2 TEST AND OPERATIONAL REQUIREMENTS

The mission support vehicle will evolve as an integral part of the MSS development and fabrication program and will utilize structures and systems previously required for other test and development activities. In its final form and before shipment to KSC, the MSV hardware will be used as part of the CAV and will be used to check out each of the initial station modules. At the conclusion of its use as the CAV, the modules will be shipped to KSC where they will be off-loaded, inspected, and prepared for installation in the test fixture.

Upon arrival of each of the MSV modules at the MSOB, they will be placed in their allocated positions in the MSV stand. Here they will undergo preliminary checks and preparations necessary to verify that docking can be satisfactorily effected. Upon completion of these preliminary steps, the modules will be connected and the various items of GSE required for MSV operation will be installed.

In its operational mode, the MSV will be capable of duplicating the autonomous operation of the orbiting station. However, it also will be capable of operating with the UTE in control. Initially, UTE control will be a required mode (prior to control station module arrival) but it will later be an optional mode utilized to increase the flexibility and range of applications of the MSV through the link up with the ground data processing and data storage system.

3.2.1 MSV FACILITY REQUIREMENTS

3.2.1.1 MSV Installation and Access Provisions

The MSV will be installed in an assembly stand in the area presently occupied by the Apollo integration stand in the MSOB high bay. The assembly stand and MSV are depicted in Figure 3.2-1; the stand will consist of a supporting truss structure with segmented floors to accommodate the assembled MSV and modules under test, access white rooms, and supporting GSE. The floors will be designed to allow their use as a supporting structure for the rails necessary for guiding the modules into a docking position with the core module. Dimensional relationships of the MSV and the MSOB floor plans and elevations are given in Figure 3.2-2. Under this concept the ± Z-axis docking ports will be normally used for the MSV modules. Access will be

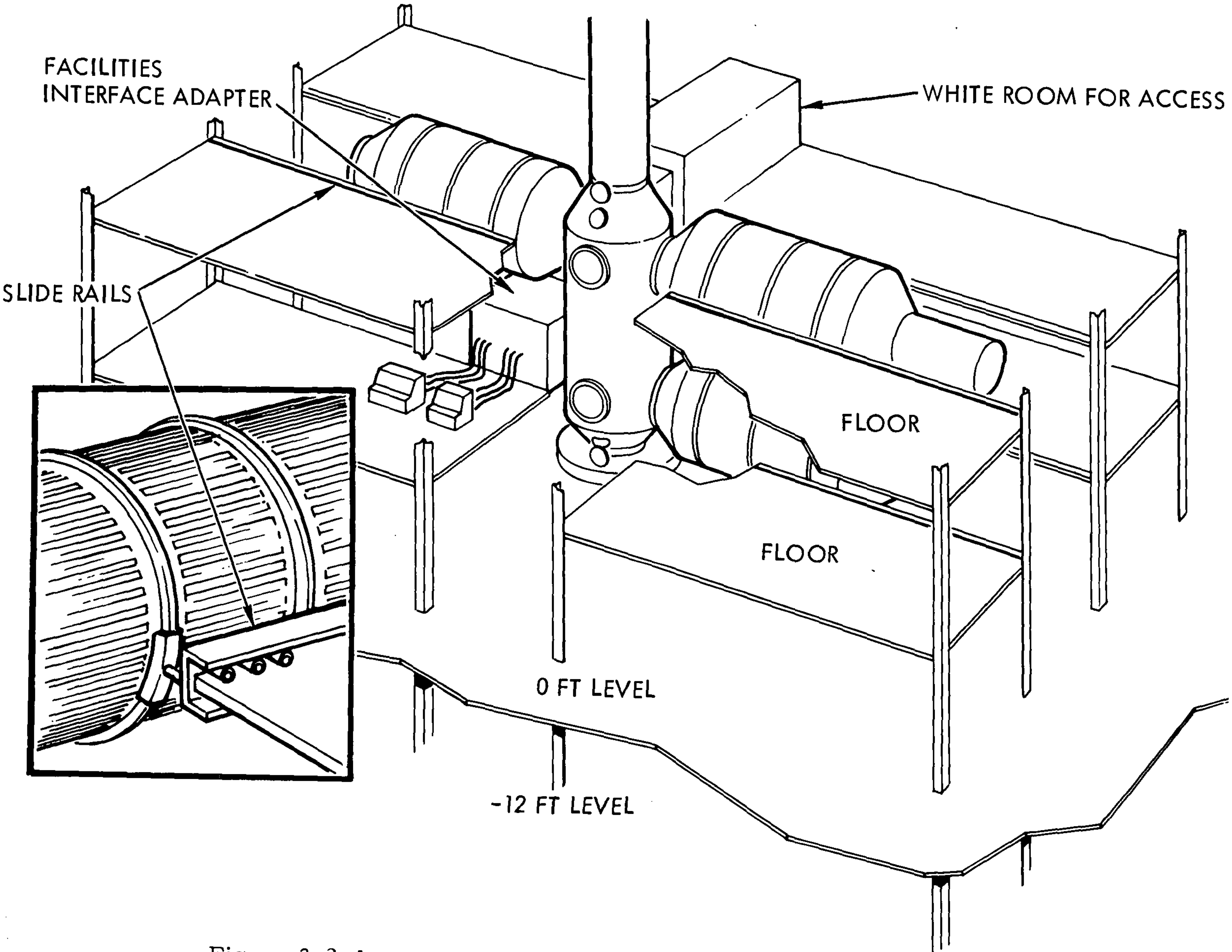


Figure 3.2-1. Mission Support Vehicle Installation—MSOB

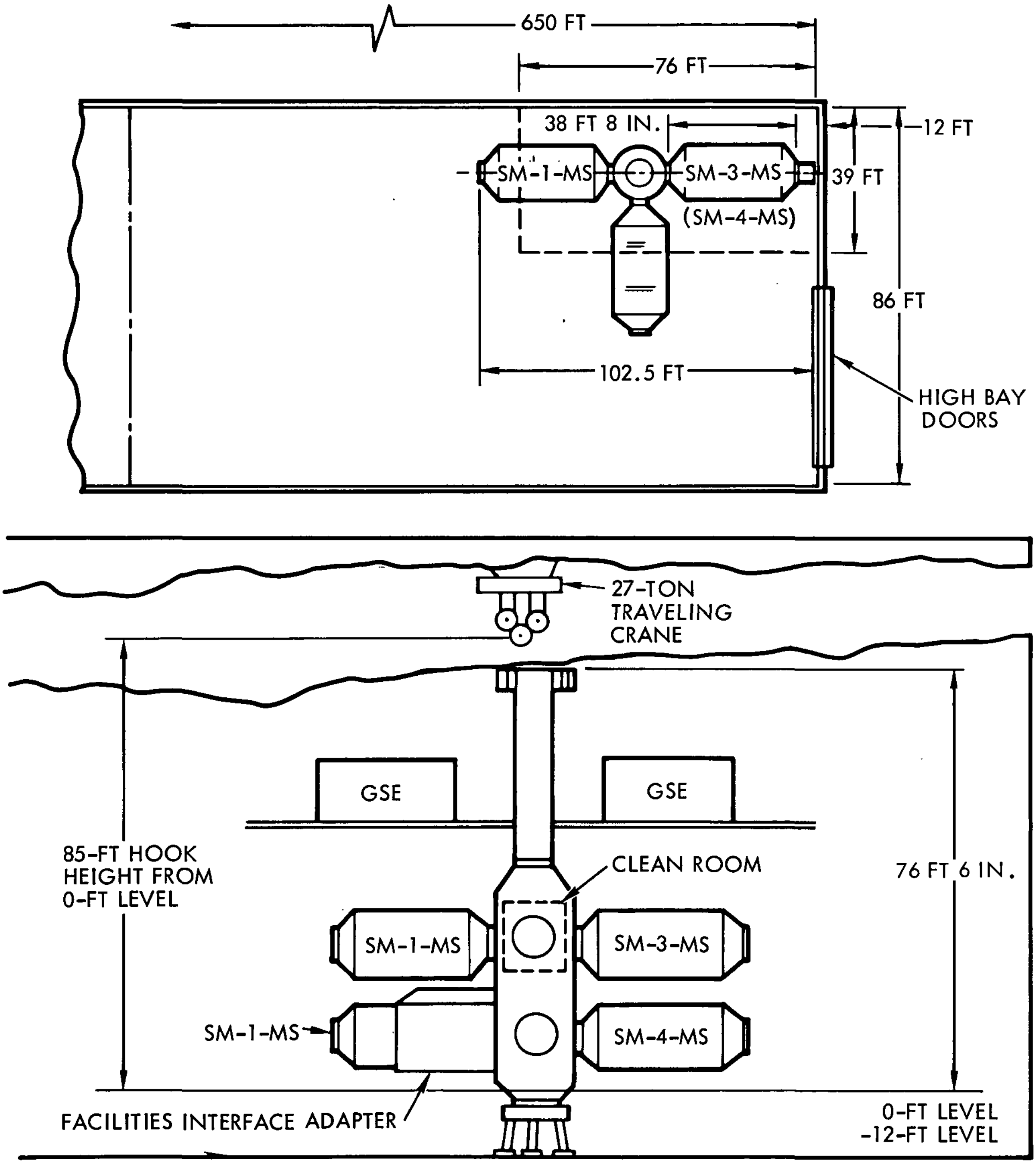


Figure 3.2-2. MSOB MSV Installation

provided through the -Y-axis docking ports. This arrangement allows the use of the two -Y-axis ports for module checkout.

Access to the external surfaces of the MSV will be provided in the form of adjustable platforms and ladders. Normal internal access to the MSV and attached modules will be through the Y-axis docking ports on the core module. Special white-room structures, or vestibules will be constructed around each of the Y-axis docking ports to maintain the cleanliness and humidity levels required inside the MSV, while providing convenient entry and exit routes for the MSS.

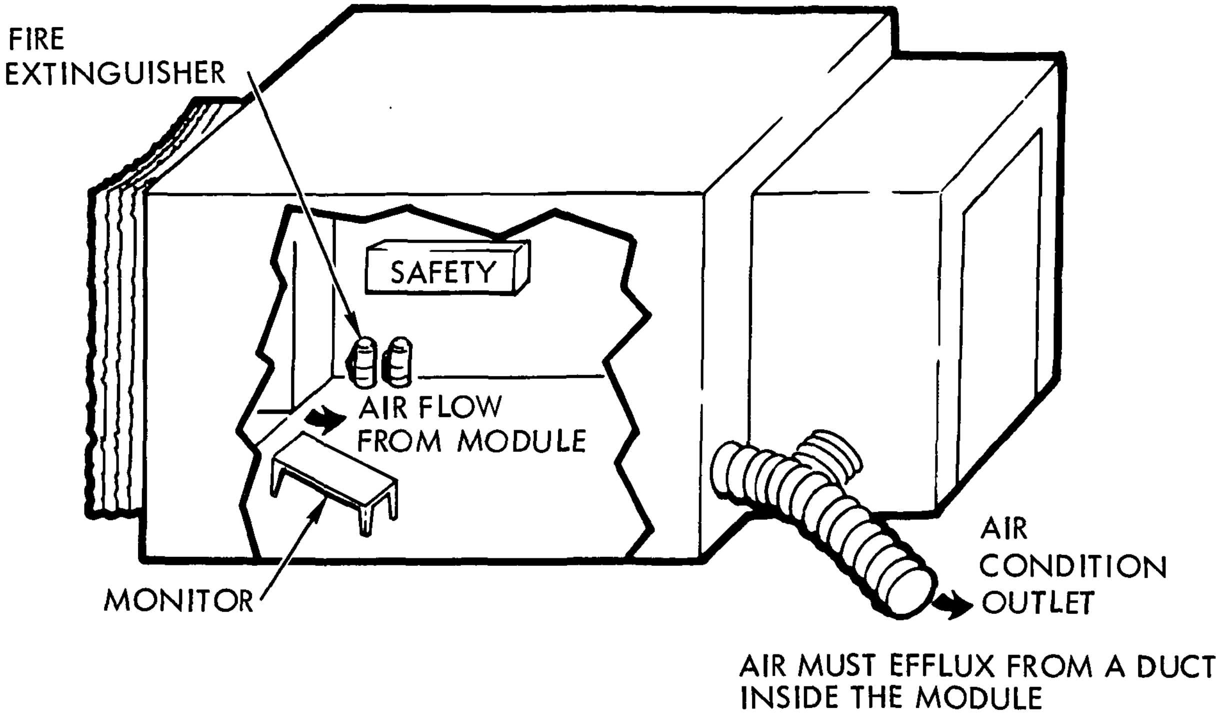
Figure 3.2-3 illustrates a white room and requirements typical of those presently in use. Modifications to these concepts will be required to accommodate the two-port MSS configuration. One concept is shown in Figure 3.2-4. It shows the upper Y-axis docking port used as the normal access route; the lower docking port is used as an emergency escape route. The air conditioning units are ducted to enable the MSV interior to always show a positive pressure in relationship to the pressure in the white rooms. This condition can be achieved by running the ducts into the MSV through the lower docking port and allowing the air to flow out into the white rooms from the MSV interior.

3.2.1.2 Ground Interfaces

While the MSV will be designed as a near duplicate of the self-sufficient MSS, its capabilities will be constrained by the fact that it will be operated on the ground. This constraint will result in the necessity to provide supporting mechanical and electrical equipment and off-board communications and control capability for the MSV.

The ground support equipment to be utilized with the MSV will incorporate the concept of utilizing universal test equipment (UTE) for the automatic control and monitoring functions. Typical major assemblies and functional flows required for the implementation of this concept are illustrated in Figure 3.2-5. The UTE is shown to consist of a complex of equipment, which includes a control and display console, standard interface units, and an automated RF test set.

The configuration shown assumes that the MSV is used to interface with the modules under test. An alternate configuration, the one which will be used for initial module subsystem verification at KSC, requires a berthing port adapter to interface services and facilities with the module under test. This concept is shown in Figure 3.2-6.



CONSTRUCTION:

MAY BE DEXION FRAME WITH PLASTIC TYPE COVERING.
MUST BE NON-STATIC PRODUCING AND FIRE RETARDANT, SUCH AS DEXION AND RCA 2400.

ENVIRONMENT:

AIR FLOW TO MAINTAIN POSITIVE INTERNAL PRESSURE WITH MINIMUM NOISE

100,000 PARTICLES $\leq$ 5 MICRONS
700 PARTICLES $\geq$ 5 MICRONS

EQUIPMENT REQUIRED:

EMERGENCY BREATHING UNITS (SCOTT AIR PACKS)
FIRE EXTINGUISHERS
TOOLS
CLOTHING (BUNNY SUITS, GLOVES, CAPS)
STORAGE CABINET
TABLE AND CHAIR

SPECIFICATIONS:

FEDERAL SPECIFICATION 209
MAO115-C12

Figure 3.2-3. MSV White Room Requirements

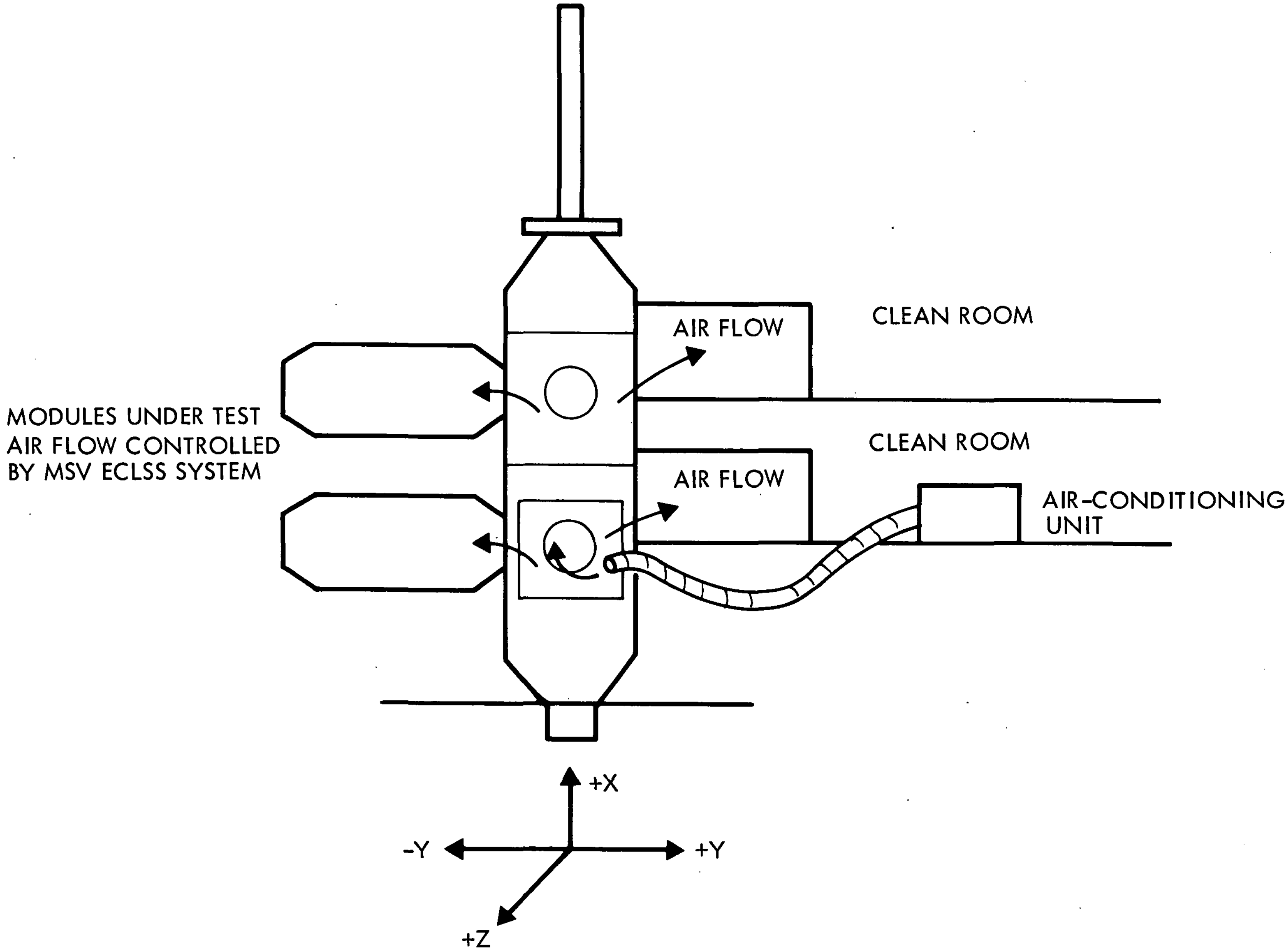


Figure 3.2-4. MSV Air-Conditioning Concept

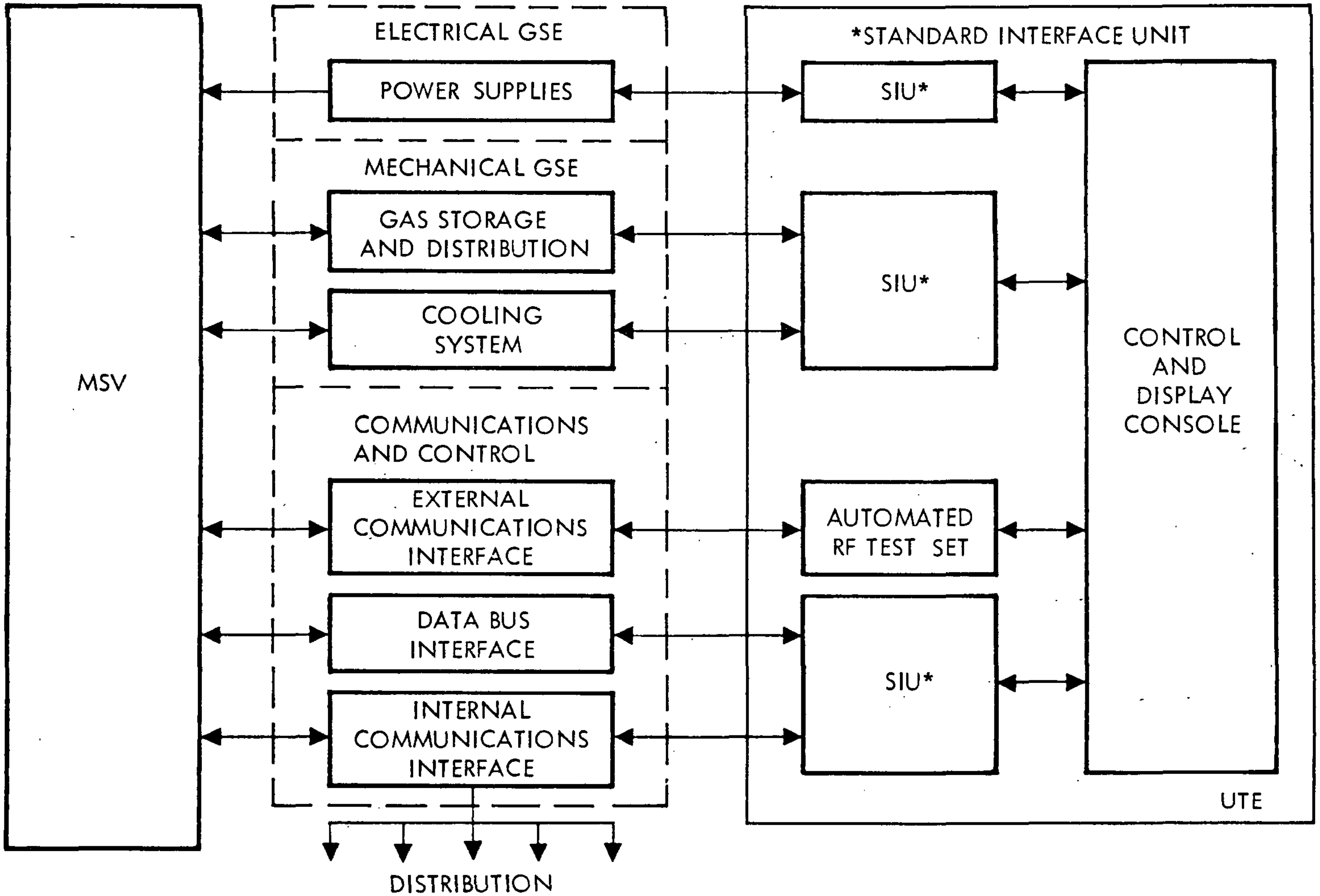


Figure 3.2-5. Typical UTE Control and Monitor System

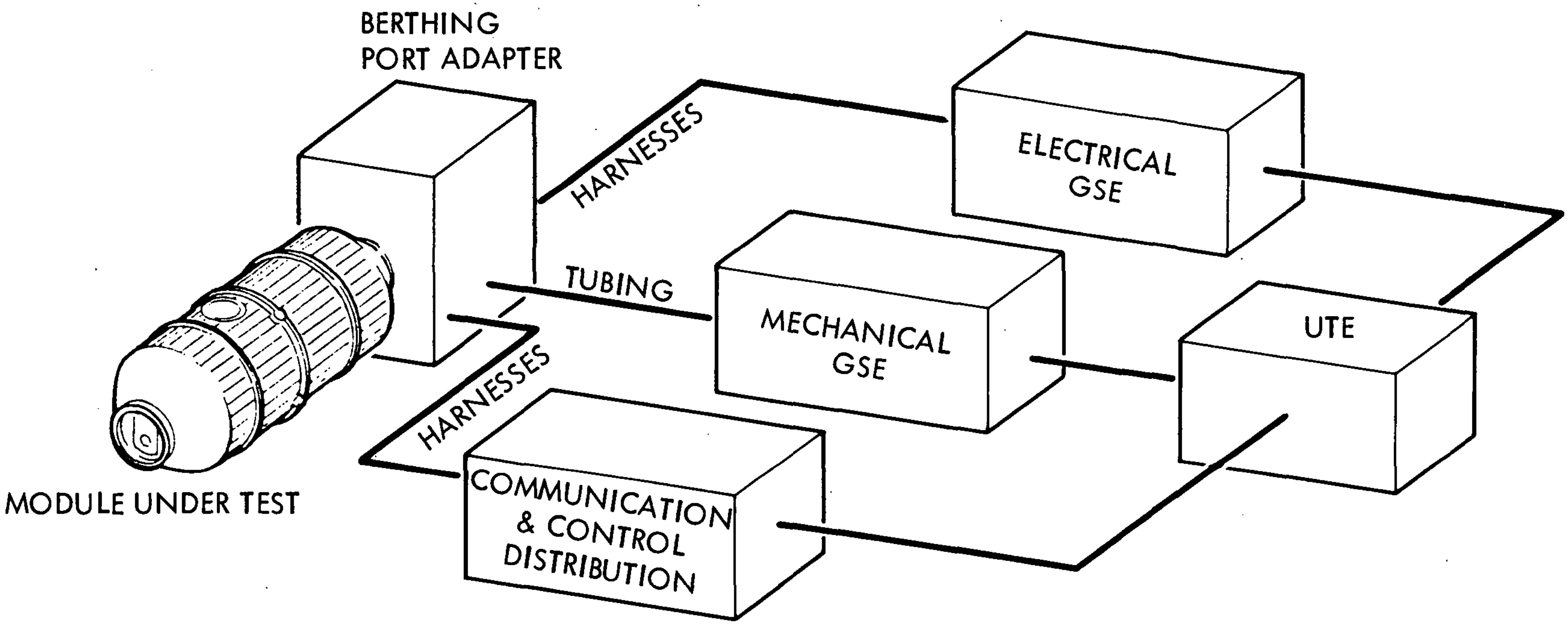


Figure 3.2-6. Single Module Checkout Setup

Electrical Power

The power requirements differ depending upon the specific test setup. When the module under test is connected to one of the MSV ports, the power is supplied directly to the MSV core module inverter inputs. The ground supplies must, therefore, duplicate the solar array power transferred across the slip rings (i. e., ± 112 vdc at 55 amperes for each of four power circuits).

When the test configuration is as shown in Figure 3.2-6, the power delivered to the module under test shall be 240/416 vac 400 Hz, 3-phase for the primary busses and 240/416, 120/208 vac 400 Hz, 3-phase and 56 vdc for the secondary buses.

Mechanical GSE

The MSV will require certain ground services to supplant on-board capabilities that cannot be used to their full advantage because of limitations resulting from the differences in orbital and ground environments. Two such services presently identified are a gas storage and distribution system and external cooling units.

Gas Storage and Distribution

Gas bottles inside the MSV will not be used to store gases, instead, external reservoirs and accumulators will be used and will be connected to the manifold systems normally fed by the storage bottles. These bottles will provide N_2, O_2, and H_2 at normal MSS source pressure of 300 psi.

Thermal Control

The thermal control system for the orbiting MSS depends upon the specially designed outer skin of the station modules for cooling by radiation. This capability will be inoperative on the ground, and the module radiators will be supplanted by a ground cooling unit.

Communications and Control

A ground-based communications and control capability will be provided at the MSV installation. This capability is required to provide ground emergency monitoring and control of the MSV and to reduce the traffic within the MSV by providing the capability for ground personnel to monitor MSV system performance from the ground.

The UTE will be utilized for the ground communications and control functions and will be used to control and monitor the performance of the mechanical and electrical GSE required to support the MSV.

Utilizing the UTE will provide the additional advantages of (1) increasing the system performance analysis capability and (2) providing the capability for checking out individual modules without disturbing the MSV operations support capabilities. Both of these advantages are inherent to the UTE as presently conceived.

UTE interfaces with the MSV communications and control systems are illustrated in Figure 3.2-5 and consist of an external communications assembly interface, a data bus interface, and an interface with the ground distribution system for the internal communications assembly.

External Communications Interface

Links to the MSV external communications assembly will be provided through RF transmission lines coupled to selected antenna feed points. The use of coaxial closed-loop transmission instead of open-loop air transmission is necessary to reduce interference when operating the RF systems inside the MSV. These links will be terminated on the ground in appropriate outfitted ground stations capable of both up-link transmission and down-link reception. The automated RF test set defined for UTE will be an integral part of this station. Table 2.1-3 summarizes the RF link requirements.

Internal Communications Interface

The MSV internal communications assembly will be tapped and made available outside the MSV. This capability will enable personnel outside the MSV to communicate with test personnel inside the vehicle. It also will permit access of MSV internal communications assembly from the ground both for monitoring and checkout of this assembly. Table 2.1-4 summarizes the MSV internal communications capabilities and will be the basis for the ground station capabilities.

Data Bus Interface

The UTE will be connected to the MSV data bus via a data bus coupler, which will allow the MSV ISS to continue to operate unimpeded. In this manner, the need for specialized connections to each of the subsystems for ground monitor and control will be eliminated. Instead, the on-board data gathering and control distribution system will be utilized through cooperative operations between the MSS ISS and the UTE.

3.2.2 MSV ACTIVATION AND OPERATIONS SUPPORT

The utilization of the MSV as an integration and checkout tool is twofold. As previously stated, the MSV will be used as a systems verification article during the initial station phase of the MSS program. Later, the MSV will be utilized to verify changes to orbital elements prior to implementation of such changes, support cargo module checkout, and serve as a replacement crew familiarization device. The MSV secondary role will be to support the transition at SM-3, which will include individual and combined systems tests of subsystems and finally the acceptance and launch checkout tests of the integrated elements.

3.2.2.1 MSV Buildup

The core module will be depackaged, inspected, and placed in the checkout stand. A special berthing port and adapter will be installed at the lower +Z-axis port as illustrated in Figure 3.2-7. This is an adapter that will be utilized to supply primary and secondary power, external cooling air, and gas supply lines for gases required for the station operation. This assembly also will be used for connecting the internal communication system to external systems. Clean rooms for entry and emergency exit will be installed on the two +Y-axis ports.

Antenna hats will be placed on the S-band antenna on the core module. In turn, these will be hardwired to the local ground RF station designated for use with the MSV.

SM-1-MS will be delivered to KSC one month after delivery of CM-2-MS. Upon delivery and initial inspection of SM-1-MS, it will be placed in position at the upper docking port on the - Z-axis of the already-in-place core module.

The radiators that normally would be used for dissipating heat from SM-1 will not be operating in SM-1-MS, instead, the coolant loops will need to be connected at this time to an external cooling unit.

RF antennas on SM-1-MS will be linked to the ground station through antenna hat/coaxial cable combinations, which will allow the operation of these systems in a simulated open-loop mode. At the completion of this activity, the MSV will be ready for power-up and system verification. Ground control and monitor will be provided by the RF links and, through the communications and control lines, provided through the adapter at the core module lower +Z-axis adapter. UTE will be utilized as needed, but MSV systems will be utilized in a simulated flight on-board checkout mode.

The next two modules to be delivered for the MSV will be SM-3-MS and SM-4-MS. SM-4-MS will be lowered into position and berthed at the lower -Z-axis port, and SM-3-MS will be berthed at the upper -Z-axis port.

Incremental verification of the facility and procedures will be performed during the installation and verification of each of the MSV modules. A final integrated test will be performed to verify facility configuration

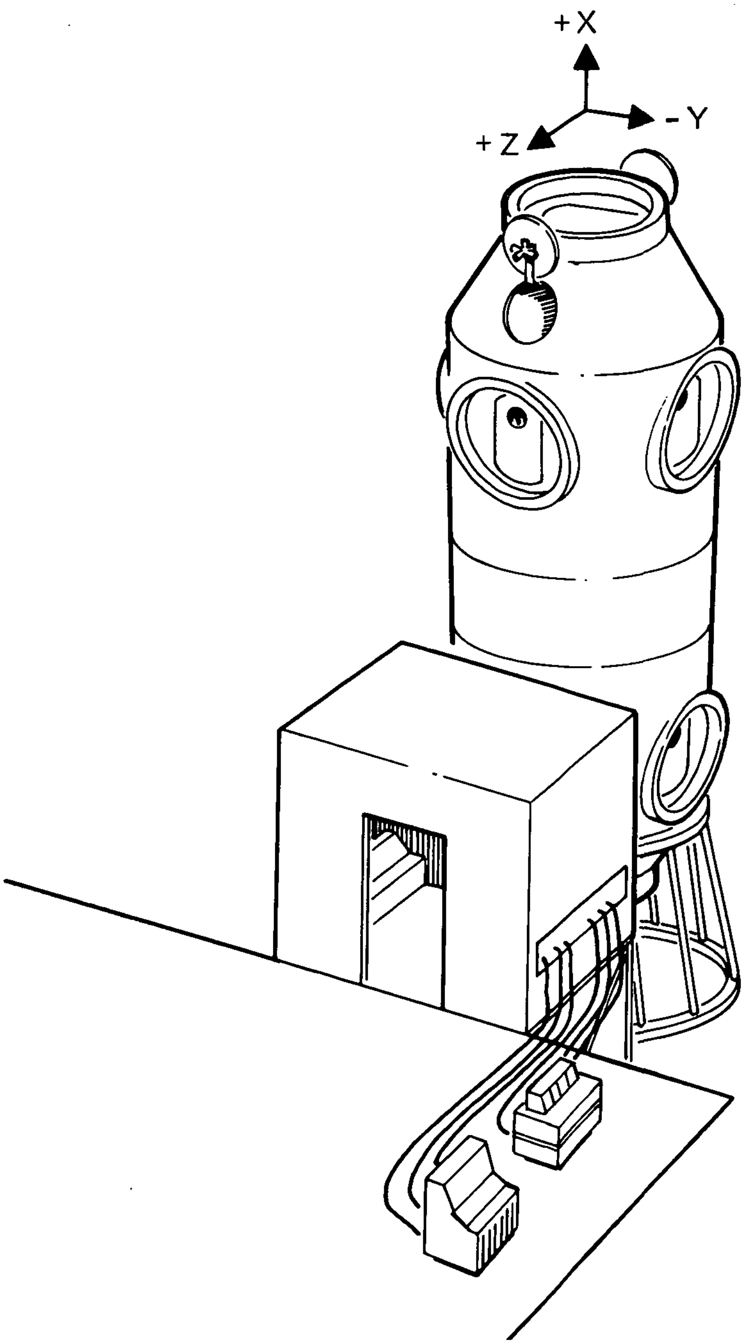


Figure 3.2-7. Installation of Special Berthing Port and Adapter

and compatibility with the MSV. All procedures and active and inactive interfaces will be verified to ensure the capabilitv of the site to operate and check out flight hardware. When this testing is completed, the MSV facility will be ready to perform acceptance testing ot SM-3, SM-4, and the cargo modules.

3.2.2.2 Operations Support

Acceptance checkout of SM-3 and SM-4 will be performed using the ports normally assigned to these modules in the flight configuration. This will require that the corresponding MSV modules be removed and substituted with the modules to be acceptance tested.

At the conclusion of SM-3 and SM-4 acceptance, the MSV modules SM-3-MS and SM-4-MS will be returned to their original positions. This will be the normal configuration for cargo module acceptance and subsequent mission support operations.

4.0 CARGO MODULE OPERATIONS ANALYSIS

The cargo module concept utilizes the MSS universal structure except that it is 24 feet in length compared to a station module length of about 39 feet. It is self-sufficient on orbit for 6 men for 72 hours when in the shuttle cargo bay. Up to 11, 800 pounds of cargo can be carried with an up crew load of 6 passengers. Passengers would occupy the cargo module only during orbital periods, and transfer to the station would be accomplished through the orbiter. One-hundred-twenty cargo containers provide sufficient dry cargo storage capacity to meet resupply and the 120-day storage capacity for all anticipated liquid and gas resupply requirements. Should this requirement ever increase, up to nine tanks can be carried in the annular volume shown in the cargo module concept illustrated in Figure 4.0-1.

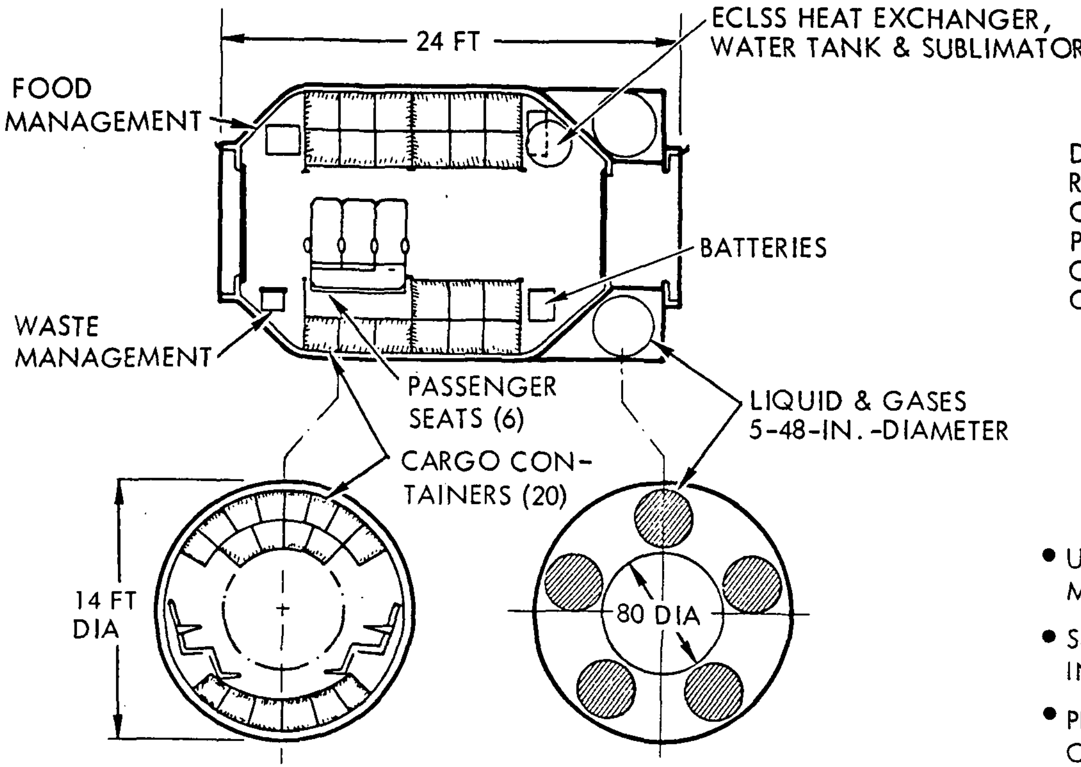
4.1 SUBSYSTEM DEFINITION

The subsystems incorporated in the cargo module (Figure 4.1-1) are basically life support systems required for the passenger and cargo arrangement. These subsystems are primarily located in the conical ends of the pressure compartment; consequently, they do not interfere with the basic cargo storage areas.

When the cargo module is converted from a passenger and cargo arrangement to an all-cargo arrangement, most of the subsystems remain in the module, and only some of the heavy, easy-to-remove items such as batteries, dry toilet, and oxygen tanks are removed. Some of the system's fluids, such as the water for the boiler (evaporative cooling), may be off-loaded.

4.1.1 ELECTRICAL POWER SYSTEM

The electrical power subsystem is designed to use shuttle or space station power when available and to provide the additional power needed to meet other subsystem requirements. The subsystem was sized for the crew/cargo mode of operation, because this mode imposes the greater power load requirement.



WEIGHT (LB)

DRY	9660
RESIDUALS	210
CONSUMABLES	460
PASSENGERS & PROVISIONS	2560
CARGO CONTAINERS	350
CARGO	11,800
TOTAL	25,000

DESIGN FEATURES

- UTILIZES MSS UNIVERSAL MODULE STRUCTURE
- SELF-SUFFICIENT (72 HR) WHEN IN SHUTTLE
- PROVIDES SHUTTLE BERTHING CAPABILITY FOR MSS RESCUE
- EASY CREW AND CARGO UNLOADING
- EASILY CONVERTIBLE TO ALL CARGO
- CREW OCCUPANCY ONLY DURING ORBITAL FLIGHT

Figure 4.0-1. Cargo Module Concept

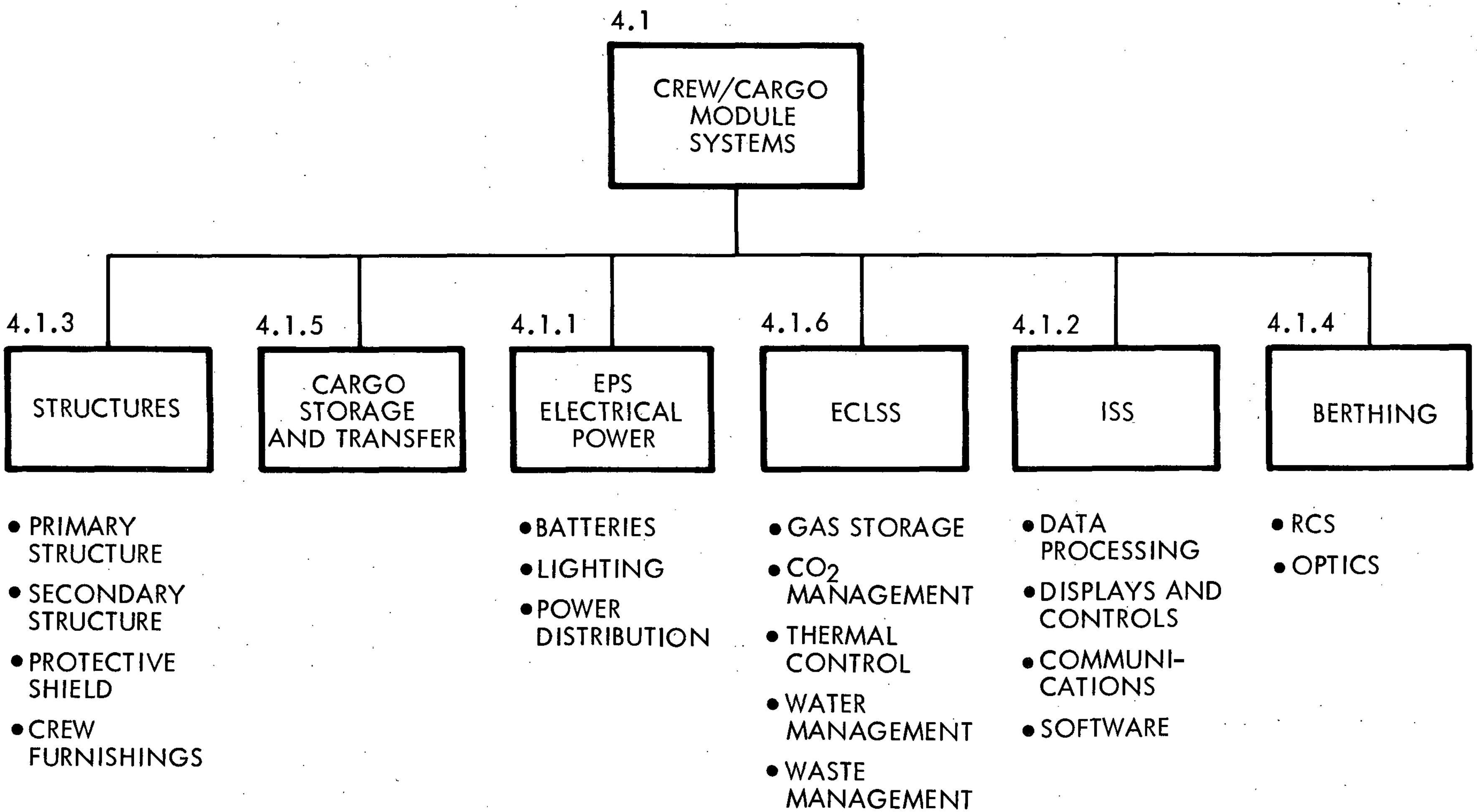


Figure 4.1-1. Crew/Cargo Module Systems Definition

As shown in Figure 4.1-2, batteries were selected as the power source with inverters for conversion to an ac system for compatibility with the station power subsystem. Sufficient energy storage capability is included to satisfy emergency power needs. A battery charger also is contained in the subsystem to allow recharging of the batteries while the cargo module is docked to the station during on-orbit stay-operations.

The electrical power distribution and conditioning equipment is compatible with that of the space station. Normal and emergency lighting provisions also are included to satisfy illumination requirements.

Provisions are included for off-loading one-half of the battery complement during the cargo only mode of operation, because the power-load requirements during this mode of operation is reduced, thus enabling greater payload capability.

The shuttle (orbiter) will provide 20 kilowatt-hours (kwh) of electrical power to the cargo module during the orbital phase of flight. The average power supplied is 400 watts with capability to supply 600 watts peak loads of 28 vdc. Power for prelaunch, boost, reentry, and recovery phases will be provided by batteries in the crew/cargo module.

The electrical loads for the self-sustaining cargo module are presented in Table 4.1-1. The normal power requirements exceed the power supplied by the shuttle orbiter necessitating the inclusion of a power source in the cargo module. Lighting demand has been adjusted to minimize power requirements. Full lighting is provided for the first 5 hours of flight, and one-half of this demand is allowed for the remainder. Power requirements during the shuttle flights are met by a combination of shuttle power and silver-zinc batteries located in the cargo module. GSE provides power while on the ground, and the station provides power while the cargo module is docked to the space station.

The batteries are sized to supply emergency power for the entire return trip, assuming power loss from the shuttle to the cargo module occurring just prior to station berthing after a 30-hour rendezvous flight phase. This represents the worst-case, because the batteries would have supplemented the shuttle power supply for the maximum time, and recharging of the batteries would not occur prior to return flight. Provisions allow for one battery failure of the two batteries installed and still meet the emergency power requirement.

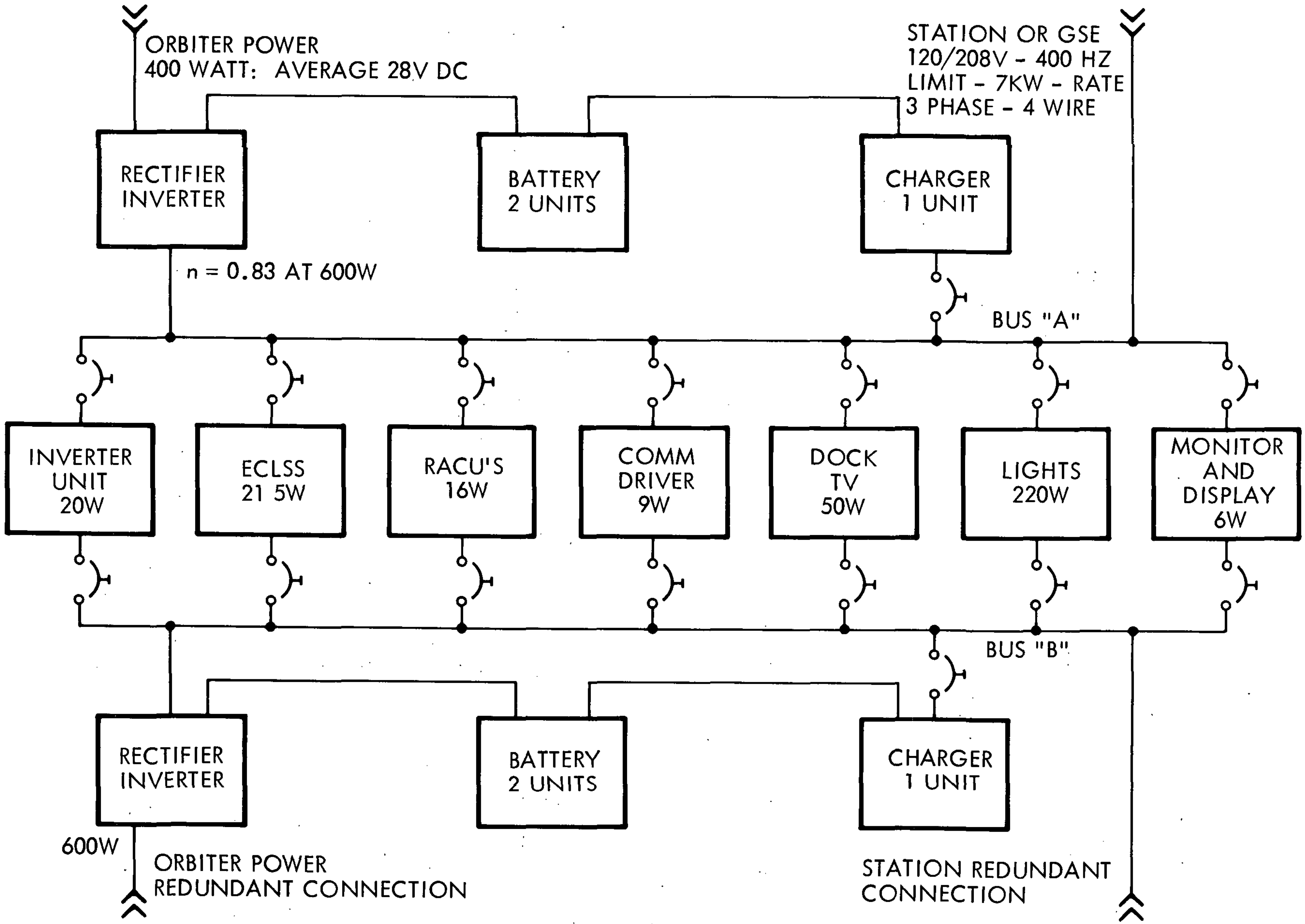


Figure 4.1-2. Schematic of Self-Sustaining Electrical Power Subsystem

Table 4. 1-1. Cargo Module Subsystems (Power—Watts)

Load \ Operating Mode	Planned	Cargo Only
ECLSS	215	100
ISS	51	36
RACU's	10	10
Interface unit	37	37
Communications (AVU)	6	
Dock TV (black and white camera)	40	50*
Local monitor alarm	5	-
Lights	220	-
Totals	537	183

*Not included in totals—short-term loads.

The power demand of the parasitic cargo module is less than that normally supplied from the shuttle, excepting a 22-minute period subsequent to launch and a 1.5-hour period at the end of the return portion of the flight. Provision to supply this additional power to the cargo module would require modification of the currently proposed shuttle power subsystem.

Lighting consists of two systems: reading lights to each seat rated at 20 watts and two emergency lights to provide emergency egress rated at 10 watts each. The power profile provides full reading lights for the full duration of the cargo mission.

Power from the 28-vdc source from the shuttle will input to 300-watt inverters (two required) and supply the cargo module with 208/120 volts, 400-Hz power. These inverters are defined as two-rectifier inverters, each rated at 300 watts at 0.85 picofarads (pf).

4.1.2 INFORMATION SUBSYSTEM

The cargo module information subsystem provides for the acquisition and distribution of data.

The information subsystem (ISS) data processing function to be performed by the shuttle's data processing system will be to perform subsystem status, monitor and alarm, and monitor the passengers status. The ISS configuration is the same for all cargo module configurations.

The ISS will interface with the ECLSS and EPS through remote acquisition and control units (RACU's). The RACU will receive commands from the data processor system and decode commands for distribution to the user and accept data from the subsystem, digitize this data, and format it for transmission to the shuttle data processor system.

The monitor and alarm display unit in the cargo module will keep the passengers informed of the status of the cargo modules' subsystems, the progress of the flight, and the status of the cargo module when docked to the space station for use as a work area.

A TV camera is mounted in the cargo module and is used to aid the shuttle crew in performing the docking maneuvers.

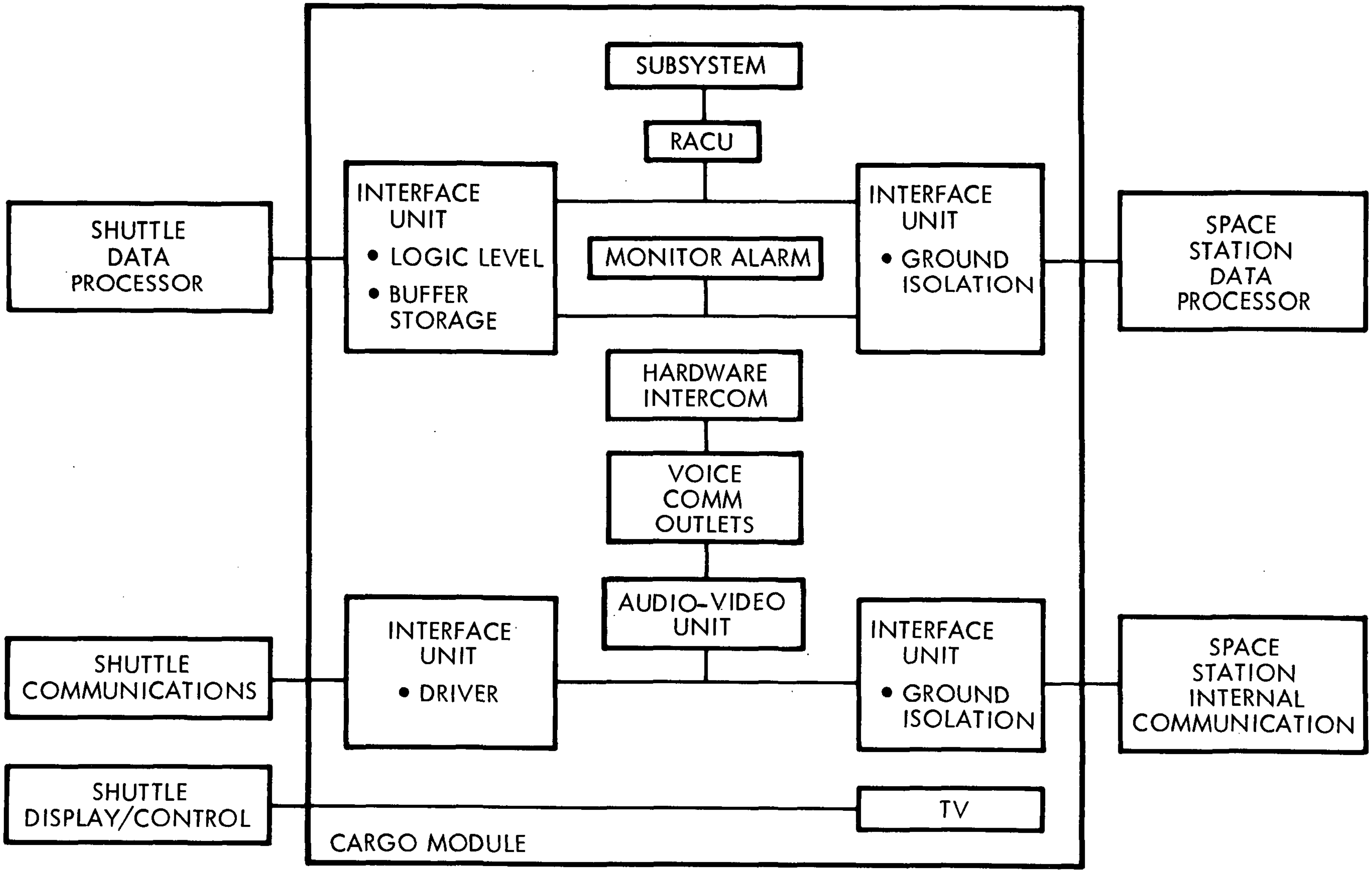
The audio-video unit (AVU) is used for voice communications between the crew and the passengers during flight. When the cargo module is docked to the station, the AVU provides telephone and video capabilities.

The interface unit located in the cargo module will provide isolation of the grounding points for the data processor and communications unit between the cargo module and the shuttle and performs digital data compatibility conversion between the shuttle and cargo module.

A block diagram of the cargo module ISS interfaces is shown in Figure 4.1-3.

4.1.3 STRUCTURES

The structure is primarily a semimonocoque pressure vessel shell with a berthing port on each end, consisting of a basic cylinder, two conical end bulkheads, two berthing ports, two hatches, and a tunnel. Secondary structure consists of floor plates, beams, frames, and tank supports. The module utilizes the MSS universal structure. Details of the structure berthing system and interfaces are given in Section 2.0.



NOTE: THE INTERFACE UNIT IS A SINGLE UNIT

Figure 4.1-3. Cargo Module Information Subsystem Interfaces

The space station personnel transfer system includes guide rails that form a track from a docked module into the core module through the berthing port. The guide rail sections passing through the docking port opening are installed after the hatches are opened. They pass through the hatch opening at one or both sides of the long dimension of the opening, along with the portable air-conditioning ducts if required. With this orientation, a clear opening that will pass a 60-inch-diameter cargo package is maintained.

The fluid and electrical feedthrough fittings are in the berthing ring sidewalls. Flexible sections of umbilicals that connect the feedthrough fittings of the two docked vehicles are installed manually. They pass through the spaces between the ring/cone fingers outside of the 60-inch opening. Thus, the umbilicals and feedthrough connectors are accessible for inspection and maintenance.

The utilities that are located at the berthing ports include the guidance and navigation berthing sensors, lights flush-mounted to the inside of the docking rings, and the cargo transport guide rails, plus the various umbilicals that are installed after the module has mated with the berthing port on the core module.

The umbilicals are installed manually by the crewmen after berthing, sealing, and the pressurization of berthing ports has taken place. Manual connection of the umbilicals has been utilized to take advantage of the crewmen ability and to eliminate the extreme design problems associated with the automatic hookup of umbilicals, which include remote connections, sealing, installation volume required, and noninterference with the docking operations. The very number of the umbilicals and the design goal for shirt-sleeve maintenance also ruled out automatic umbilical hookup.

Figure 2.1-35 defines the minimum clearance envelope through the docking port opening (and the core module where required) to allow the passage of the 5-foot-diameter cargo. The cargo transport guide rails are manually installed across the docking port by the crewmen after the hatches are opened and lies between the cargo envelope and the docking port opening. The guide rails form a track from the docked cargo module through the docking port and into the core module to the area where the cargo is installed.

The location of the various utilities umbilicals are shown in Figure 2.1-35. As noted, all of the umbilicals are installed to clear the 5-foot-diameter cargo. Sixteen of the umbilicals are installed through the spaces between the cone fingers and two between the cargo envelope and the docking port opening. The umbilicals include two air ducts, hard lines for H_2, O_2, and N_2, water lines, and electrical harnesses for power and control.

The electrical harnesses are of a dual system, and each set of harnesses has been separated in the installation. Hinged umbilical protective covers are utilized to allow access for installation of the 16 umbilicals within the cone finger spaces and for protection from damage after installation.

The guide rails and two of the air-conditioning ducts (supply and return) are installed through the berthing port opening and, therefore, must be removed to allow the closing of the hatches.

All of the umbilicals, guide rails, etc., are installed within the pressurized area between the pressure hatches and thus are in a shirt-sleeve environment for crewmen installation and maintenance of the utilities.

The installation of all the utilities, as described, are the universal accommodation at the core module berthing ports to which the cargo module (CM) attaches.

The shuttle berthing interface is located above the crew compartment and is fitted with an adapter for docking to the space station. Figure 4.1-4 depicts the shuttle vehicle docked with the space station positioning a cargo module with the shuttle payload manipulator.

4.1.4 CARGO STORAGE AND TRANSFER

The storage tanks located in the cargo module provide the gases and water necessary for resupply of the space station, RCS, EPS, ECLSS, and experiments. The gases are stored at a pressure of 3000 psi. The number and location of the tanks are shown in Figure 4.0-1.

Preliminary investigation of the logistics support requirements for the space station suggests that standardized packaging sized to accommodate approximately 5-plus cubic feet is applicable to the vast majority of cargo items. Gross weight of the container is expected to average 50 pounds, which is well within the handling capabilities of the individual crew members.

Cargo removal preparation consists of installation and activation of the mechanical cargo transfer system identical to that in the space station. This system consists of guide rails and powered trolleys. The guide tracks are permanently installed in the main station longitudinal passageway and transversely from each of the docking ports to the main passageway guide track. The guide tracks that extend into and mate with the tracks in the cargo module are either hinged or removable sections that are stowed in the space station prior to installation. Installation is considered part of the cargo module preparation procedures.

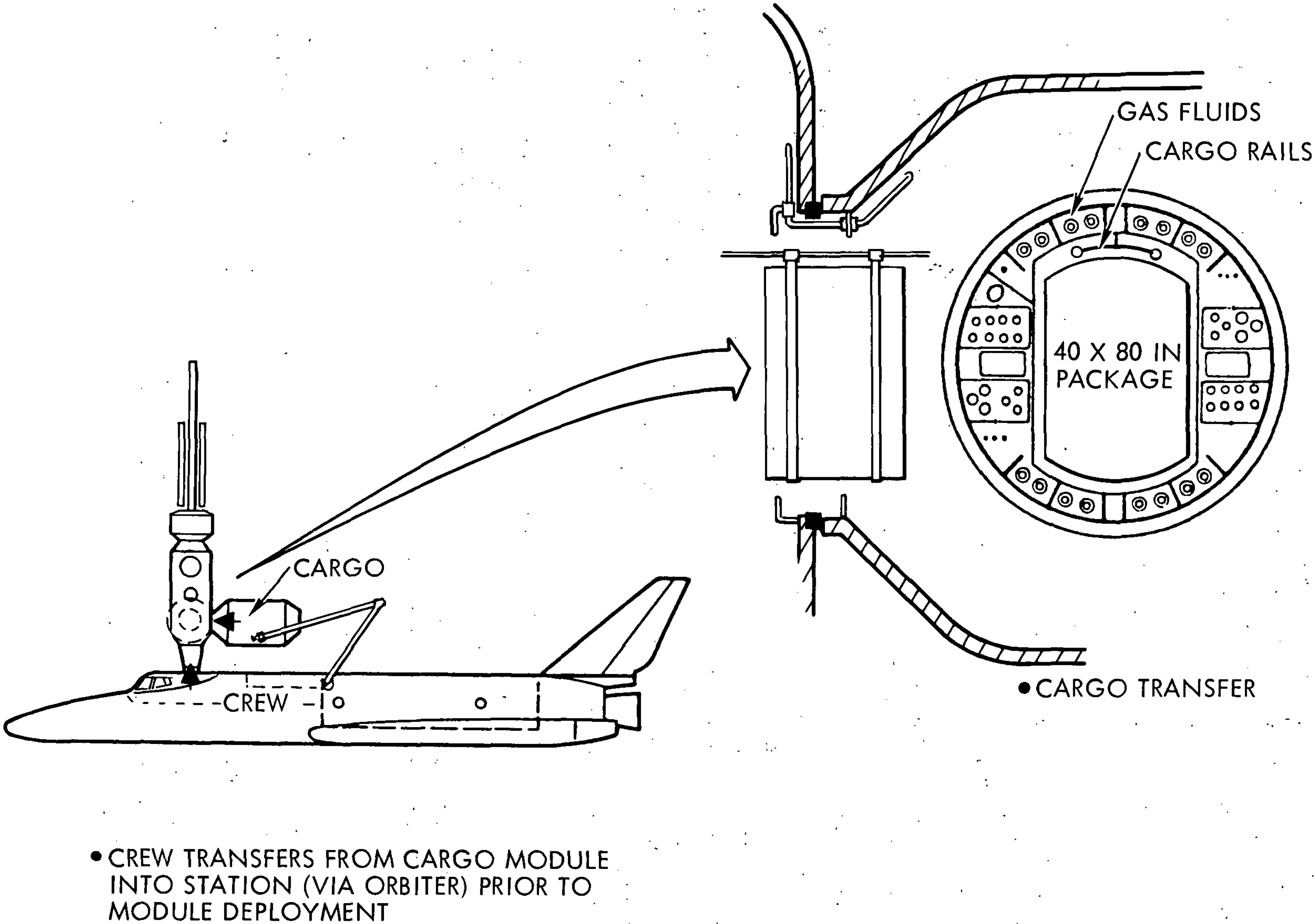


Figure 4.1-4. Crew/Cargo Transfer

A cargo container attached to a trolley in the cargo module can be translated by remote control to the longitudinal track without releasing it from the original trolley before it is fastened to the longitudinal trolley. This method provides complete control of a given cargo container during transit from the cargo module to the station cargo storage area or vice versa.

4.1.5 ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM

The environmental control life support subsystem (ECLSS) provides essential atmospheric gases, temperature, pressure, humidity control, food storage provisions, water and waste management, personal hygiene facilities, and materials for cargo module operation. The cargo module for the initial station will be configured to support 6 passengers for a period of up to 72 hours. In addition, special life support capabilities are provided for emergency conditions.

Atmospheric gas for the habitable compartment is provided by a two-gas system from storage bottles of GO_2 and GN_2. (Details of the system are described in Section 2.0 of this report). Atmospheric control (temperature, pressure, and humidity) is maintained by an assembly comprised of a circulation duct, condensing heat exchanger and fan, pressure controls, and a local fan. Carbon dioxide in the atmosphere is maintained at desired levels by circulating the cabin air through lithium hydroxide canisters. Charcoal contained in the canisters satisfies contaminant removal requirements.

Temperature control for both equipment and passengers is accomplished via air circulation through a condensing heat exchanger. The waste heat is rejected by the active thermal control assembly utilizing water sublimation techniques during launch and on-orbit operations and by freon backing techniques during reentry.

Individual water containers are provided for each passenger to satisfy drinking requirements. Two Apollo-type urinals and a dry john are provided to handle passenger wastes. In addition, a waste storage bin is provided for miscellaneous-type waste materials. A portable vacuum cleaner is provided for general housekeeping, for liquid spills, and loose food cleanup.

A reconstitution unit is provided for use with rehydratable food. Special life support provisions consist of emergency O_2 supplies and two CO_2 fire extinguishers for small fire control.

Because the mission duration is only 44 hours, the Apollo/LEM-type of LiOH cartridges and housing was selected for CO_2 removal. These cartridges are off-the-shelf.

Air temperature and humidity control as shown in Figure 4.1-5 is provided by a condensing heat exchanger sized to remove both the latent and sensible heat loads. A bypass duct from this loop diverts air through the LiOH for CO_2 removal. An air distribution system delivers the tempered and purified air throughout the cargo module. Return air flows to the heat exchanger inlet from the flow pattern induced by the air supply and distribution system. No return duct system is required.

Crew comfort is supplied by the ducted flow and a local circulation fan, which produces a nominal 40-fpm air velocity. The local fan is located to aid in developing the desired overall air flow pattern.

The pressure control assembly provides for total pressure control by only supplying makeup oxygen. No nitrogen makeup is required, because the partial pressure of oxygen will only increase in one day from 3.1 to 3.3 psia. This is within the 3.1 to 3.5 allowable partial pressure O_2 band. Single gas control simplifies the pressure control subassembly.

Trace contaminants do not present a major problem for the very short cargo module mission durations. Therefore, as in the Apollo CSM and LEM, only charcoal is provided for odor removal. The charcoal is included in the LiOH cartridges.

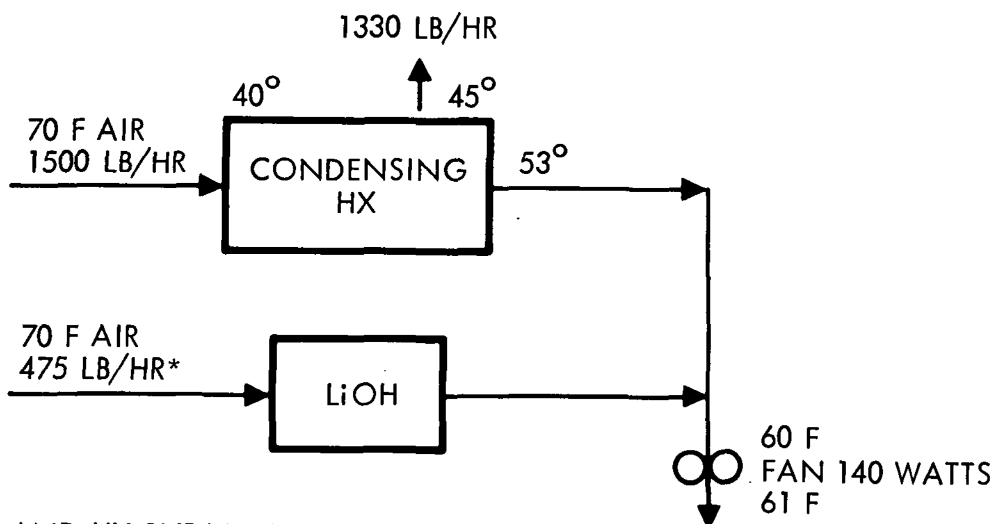
The only hardware in the cargo module requiring a coolant loop is the condensing heat exchanger. Therefore, a water coolant loop is provided to cool this heat exchanger. This loop gives up its heat to a water sublimator or freon boiler. Freon boiling is used for ground and low-level thermal control, because water does not sublimate until an altitude of 113,500 feet is reached. In space, water sublimation is used to reject the heat load. Water is used to reject heat because of its high latent heat, relatively low weight, and nontoxicity. Figure 4.1-6 presents a schematic of the active thermal control with a summary of key points concerning the choice of a water sublimator over a radiator.

A water storage tank is provided to supply drinking water. Waste management is provided by two vacuum dump urinals and one dry john vacuum vent toilet. The dry john is capable of receiving wet paper type trash wastes in addition to feces. Dry paper type trash will be stored in bags. The hygiene system consists of wet wipes for hand and face washing.

ATMOSPHERE HEAT LOAD:

SENSIBLE Q:	3300	CREW SENSIBLE, 10 MEN (GROWTH STATION)
	1000	LiOH
	2110	ELECTRICAL EQUIPMENT (618 WATTS)
	0	WALL LEAK
	6410	
LATENT Q:	1250	CREW LATENT, 10 MEN (GROWTH STATION)
	7660	BTU/HR TOTAL

PERFORMANCE: → 300 CU FT MIN LOCAL FAN



*LiOH FLOW AND HX BYPASS AIR

Figure 4.1-5. Atmospheric Control

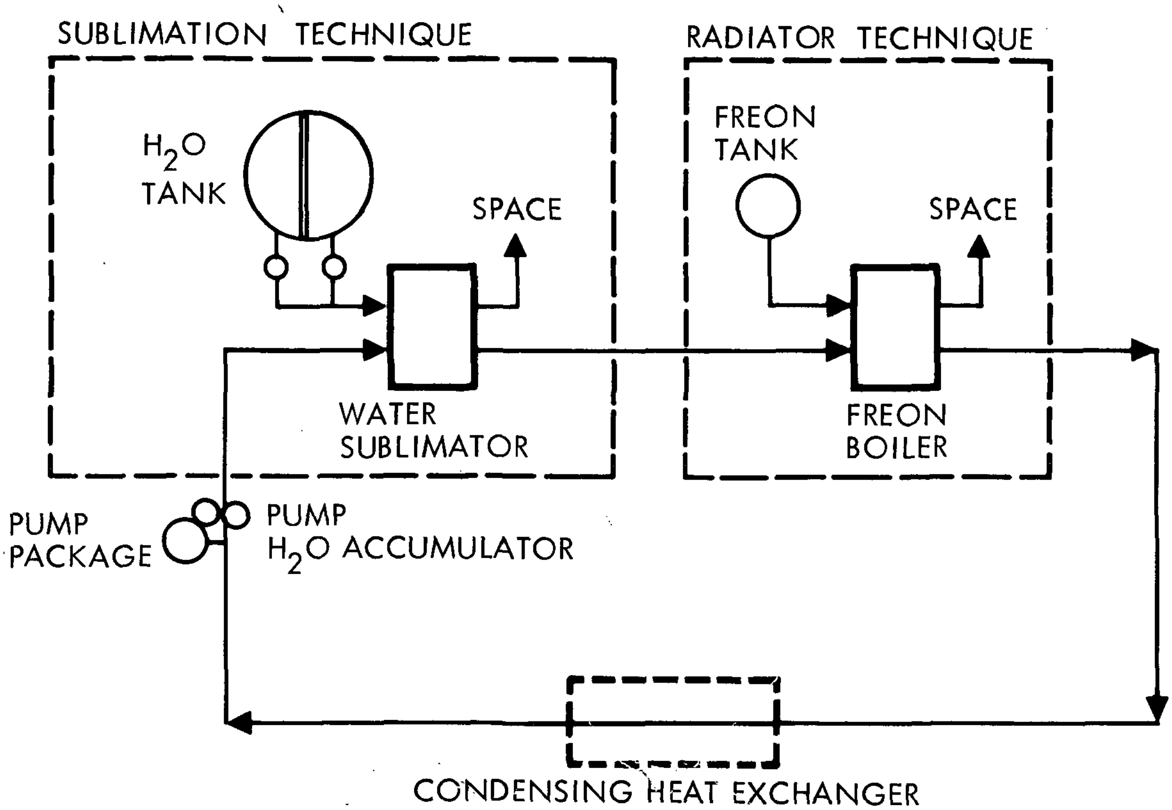


Figure 4.1-6. Active Thermal Control Schematic

Food management consists solely of bite size dry food. Snack-type items are envisioned, such as bite-size cheese, meat, and fruit cubes. Powders for fruit drinks and other cold drinks will be provided. No hardware for rehydration other than in Apollo-type reconstitution unit is provided.

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4.2 TEST AND OPERATIONAL REQUIREMENTS

The cargo module test and operational requirements have been established on the basis of handling, servicing, loading cargo, configuring for missions, shuttle operations, and return operational phases. A typical recycled cargo module operation is illustrated in Figure 4.2-1.

4.2.1 OFF-LOAD AND TRANSPORT TO CHECKOUT SITE

Handling and transportation operations will be required for initial receipt of modules and for modules returned from orbit for recycle. The modules must be transferred from the landing site to the checkout building by land conveyance. No special equipment for cooling, instrumentation, or electrical power has been identified during this study. A transporter (upon which equipment may be shipped), tug, and normally used safety vehicles will be required during ground movement.

The cargo modules will be moved into the checkout facility for pre-loading operations. A visual inspection of the module will be conducted to determine any specific work that may be required.

4.2.2 RECOVERY/RETURN/INSPECTION AND PREPARATIONS FOR CHECKOUT AND TEST

The cargo modules will be inspected visually to determine whether or not damage was incurred during shipment or while on a mission as applicable.

Standard maintenance routines will be conducted in accordance with a maintenance plan. The module will be cleaned throughout and prepared for placing it in the proper configuration for the next assigned mission.

4.2.3 SYSTEM VERIFICATION TEST DESCRIPTIONS

4.2.3.1 Subsystems Tests

As noted in Section 1.0, the acceptance tests for the cargo modules received from the factory will be performed at the launch site, because it will have the mission support vehicle (MSV) during this time period. Table 4.2-1 summarizes the subsystems, tests, and supporting requirements.

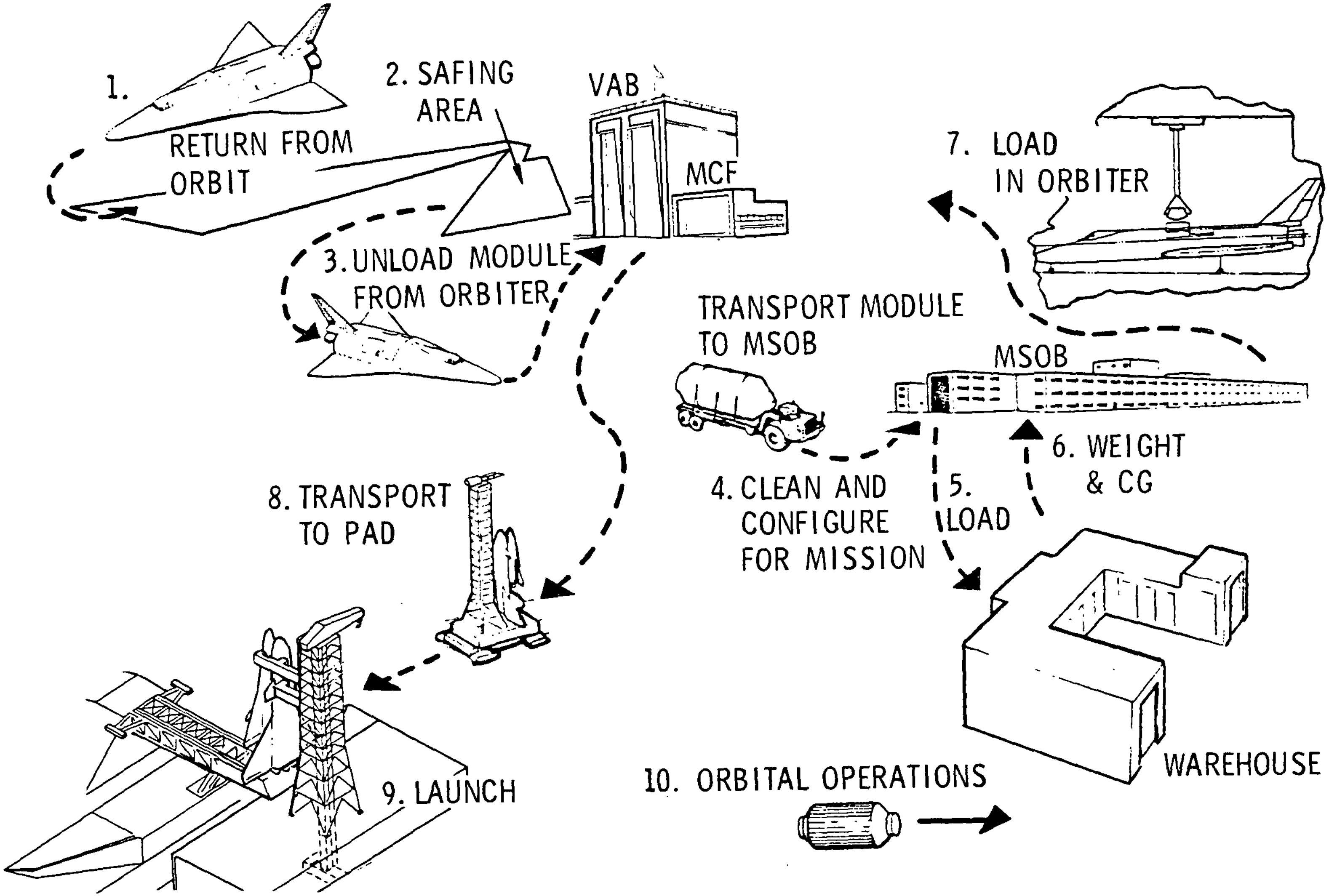


Figure 4.2-1. Recycled Cargo Module Operations

Table 4.2-1. Cargo Module

System	Test and Operational Requirement	Purpose and Rationale	Test and Operational Technique	Support Requirement	
				MSV	GSE
EPS					
Batteries Inverters Lighting Battery charger	Perform a functional evaluation of the batteries, inverters, lights, and battery charger	Verify functional performance to ensure no degradation from shipment or return from orbit.	Batteries will be checked against a load bank, and a battery laboratory will be utilized. Specific gravity of the electrolyte will be checked.	X	Hydrometer battery handling equipment Load bank similar to A14-074 on Apollo
Circuitry	DC power activation for displays and lights	Verify proper operation of systems.	Provide dc power to CCM at orbiter/station interface.	X	28-vdc 400-watt average 1.43/21.4 amperes Light meter
Circuitry	AC power activation	Verify proper operation of systems.	Provide ac power to CCM at orbiter/station interface.	X	120/208 vac 400 Hz 3-phase 4-wire 7-kw rate
ISS					
RACU, monitor and alarm, TV camera, audio-visual unit (AVU), interface unit	Verify functional performance of the RACU's, monitor and alarm, TV camera, audio-visual unit to ensure proper operation after shipment or mission completion.	To ensure operation of the system for orbital resupply operations. Checks to be made for initial verification and as required for maintenance or modification reverification. To ensure proper operation of the television system to support docking and berthing operation.	Check RACU, monitor and alarm, and the interface unit with the MSV. Check TV and communications with the MSV modules.	X X	
Structures					
Primary and secondary structure Environmental protection system	Verify integrity of the pressure volume to maintain environmental pressure. Verify the integrity of the environmental protective shield.	To ensure the capability to maintain habitable conditions during mission. To ensure the integrity of the meteoroid protection shield.	Pressurize the module to one atmosphere, and perform a pressure decay test. Visually inspect the environmental protective shield for damage from shipment or incurred while on station in orbit during resupply mission.	Optional	Equipment required to pressurize the module through the interface and monitor the pressure in the module
Ground handling	Offload from carrier (Guppy for delivery, orbiter for missions)	To transport the CCM to the preparation facility.	Off-load and transfer over land. Handling in building will be supported by overhead cranes.		Prime mover handling set transporter cranes.
	Determine weight and cg. location.	To ensure module is within allowable limit and orbiter loading placement can be determined.	Two overhead cranes and four load cells to perform weight and c. g.		Cranes load cells, handling set
Berthing					
Berthing ports ducting and plumbing Electrical and signal	Verify berthing port/hatch functions (opening and closing), docking and berthing, and port/hatch leak checks. Verify electrical and mechanical interfaces.	To ensure proper hatch operation and sealing. To visually and functionally check interfaces across the docking surface.	Operate hatches and mate to simulator or MSV. Perform docking port leak checks, and verify module leak decay rate tolerances.	X X	Hatch seal protectors, Pressure regulators Instrumentation power
Berthing G&C *Docking sensor* electronics	*Verify operation of berthing* alignment system to ensure performance prior to launch.	*To demonstrate and verify* that operating performance has not been degraded during shipment or prior missions.	The tests to be accomplished using the MSV for berthing.	X	Power source
Cargo Storage and Transfer					
Guide rails Powered trolleys	Verify transfer rail installation across the berthing interface. Verify powered trolley operation.	To ensure operability of the trolleys across the interface. To ensure that the rails can be readily installed on orbit.	Install the guide rails between the cargo module and the MSV, and operate the trolleys across the interface.	X	

Table 4.2-1. Cargo Module (Cont)

System	Test and Operational Requirement	Purpose and Rationale	Test and Operational Technique	Support Requirement	
				MSV	GSE
Cargo loading	Vertical transition for loading.	To load nontime-critical cargo.	Rotate the module to vertical, transfer to loading facility, and install loader.		Handling set Vertical transporter Loading set Vertical work stand
ECLSS					
Atmospheric control Gas monitoring Pressure control Storage	Verify CO_2 sensor unit and CO_2 removal units (LiOH canisters). Perform high-pressure gas system leak checks. Verify pressurization, circulation, and venting performance of the atmospheric control system.	To ensure system is functional for manned missions. To verify no leaks in high-pressure gas system. To ensure pressure relief system and fan performance.	Test CO_2 sensor with test set and visually inspect LiOH canisters Pressure system to 25% burst. Use suitable leak detection device. Combine with above test.	X X	Facility O_2 and N_2 regulated leak detection equipment.
Active thermal control Water coolant loop	Perform freon/water servicing and leak check.	Provide coolant to the thermal control system.	Verify system is clean and dry, then evacuate for servicing.		Freon servicing equipment, water servicing equipment, leak detection unit, vacuum pump

A recycled core module will undergo a returning inspection during the deservicing and cleaning period.

The CCM will be configured to suit the programmed mission for which it will be used. Any necessary changes of rails, shock struts, tie-down points, etc., will be accomplished in the MSOB. The passenger compartment will be configured for the mission by removing or installing equipment, such as seats, EVA equipment, emergency equipment, food and water, storage provisions, tools, and other mission equipment. System verification testing will be performed as required on the MSV.

4.2.3.2 <u>Cargo Loading</u>

An analysis of cargo loading and unloading conducted during Phase B led to the following conclusions that were used in this document as guidelines and criteria for operations:

1. Vertical cargo loading and unloading is easier and faster than horizontal.

2. Vertical cargo loading concept uses transverse floors.

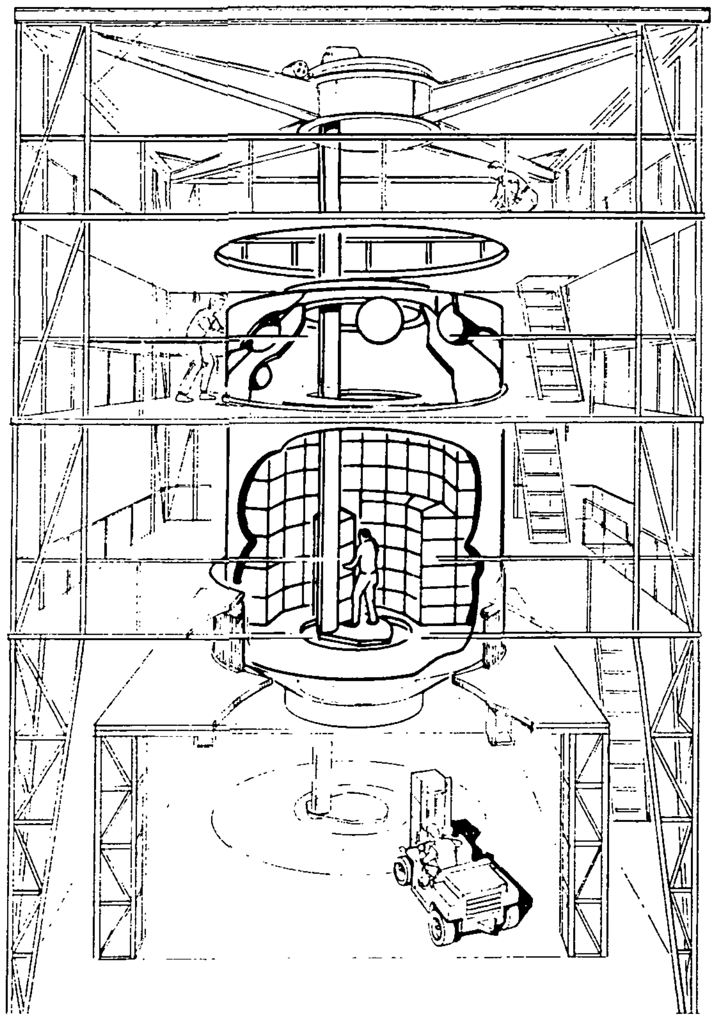
3. Prepackaged cargo will be in standard size containers of 50 pounds each.

4. Four of these containers will be palletized (i.e., held together in such a way that they can be ground handled, transported, and loaded as one unit).

5. Containers will be on the order of 19 to 25 inches square.

The cargo module (CM) will be placed in a removable workstand that also will support the semirigid telescoping cargo loader. The cargo-loader will be suspended down through the two open docking ports and cargo will be loaded onto a platform and then raised to the appropriate level (Figure 4.2-2). At the appropriate level, the platform can be rotated radially for cargo transfer into position in the module. When there are to be passengers, the seats are installed upon completion of the cargo loading.

Upon completion of the nontime-critical cargo loading, the CM will be transported back to the MSOB (approximately 700 feet) for weight and balance operation. If the center seats were removed for cargo loading of a passenger mission, they will be installed prior to accomplishing the weight and balance.



VERTICAL LOADING

SUITABLE FACILITY

WAREHOUSE

CANDIDATE GSE

A7-35 S-II TANK ENTRY

H14-124 CSM STAND

Figure 4.2-2. Cargo Loading

All cargo is expected to be prepackaged in suitable containers, pallets, or tie-down equipment. Package size will be established by several requirements (standard containers, sensitivity to launch environments, weight, etc.,) as well as the 60-inch-diameter docking port clear opening restriction.

Cargo-handling GSE will be required, such as slings, dollies, cargo transporter (to match up with cargo module guide rails), etc.

Approximately 400 pounds of frozen foods are expected per flight on a normal resupply mission. No mechanical refrigeration will be required if the goods are subcooled to -100 F and packed in a precooled insulated container. A requirement has been established that the insulated container may rise in temperature from -100 F to +15 F within 72 hours. If the launch window of 60 seconds is not met, a hold period of 15 hours would not adversely affect the above requirement. A second hold of 15 hours would probably require the frozen food to be removed and rechilled in the insulated container.

At the completion of nonhazardous and nontime-critical cargo loading, the core module fore and aft hatches may be closed and secured in a temporary manner. These hatches will be used at the launch pad for passenger boarding.

4.2.3.3 Weight and Center of Gravity

The purpose of this test is to obtain subassembly weight and the location of center of gravity. Knowledge of actual component weight compared to theoretically calculated weight is required to determine compliance with design requirements. Orbiter limitations for the center of gravity (c.g.) location that establishes the requirement for this test are depicted in Figure 4.2-3.

The following requirements will be met:

1. The weight of the subassembly should be determined to the specified accuracy.

2. All hardware that is not part of the flight configuration should be removed prior to weighing the component, if possible. If it is not possible to remove nonflight articles, their weights and locations must be known.

3. If the longitudinal center of gravity is required, the subassembly will be weighed with its geometric centerline parallel to a horizontal plane and weight reactions taken to enable calculation of this center of gravity.

4. If a requirement exists for determining the radial center of gravity, it may be determined by two weighings. Each weighing will have the geometric centerline parallel to a horizontal plane but will be rotated 90 degrees from each other around the geometric centerline. Sufficient weight reactions will be taken to calculate their radial center of gravity.

The numerical data associated with weighing operations will be observed and recorded on the weight data sheet.

The weighing operations include a calibration of the load cells. These data also will be recorded on the weight sheet.

Documentation of the weight of all the actual flight items mission from the cargo module (CM) at the time of the weighing operations will be included in the weight status log. This will include the high-pressure gases for resupply of the MSS. Dimensional measurements on the load cells/CM setup will be made and recorded for the support of center-of-gravity calculations. These measurements will be recorded on a drawing showing the arrangement of the load cells relative to the CM for the positions for which weight measurements are taken. A weight and balance log will be maintained after completion of the weighing operations. This log will document the weights and numbers of each part added to or removed from the CM.

If the necessary handling equipment is available and the structural design of the CM permits, a two-point weighing system can be used to determine the weight and longitudinal center of gravity. If the radial center of gravity is required, a three-point suspension system can be used; however, a four-point system is preferred if it will satisfy the accuracy requirements.

Because of its greater accuracy and repeatability, a weighing system that keeps the load cells in tension should be used in preference to other systems. If compression cells are used, care should be taken to avoid side loads; a weighing system that incorporates a standardizer (certified by the Bureau of Standards) can be used if it checks the complete weighing system (however, it must be calibrated every 3 months).

Periodic calibration will be made of the load cells through their full range. Point calibrations of the weighing system will be made using a weight (within 30 percent of the nominal weight of the module) certified as a secondary standard if possible. This will provide an end-to-end verification of the system.

The weight and balance operation is complicated somewhat by two factors: (1) the late loading of passengers and (2) the late loading of hazardous and time-critical cargo. These weights must be known at the time that nonhazardous and nontime-critical cargo is installed.

4.2.4 MOVE TO VAB AND LOAD IN ORBITER

Upon completion of the checkout, servicing, cargo loading, and determination of weight and center-of-gravity location, the cargo module will be transported to the shuttle checkout and maintenance facility at the VAB.

The module may be loaded at any appropriate location within this facility, but for purposes of description, it will be assumed that this will be accomplished in high bay 2 of the VAB.

Transportation requirements will include the same equipment and support as was required for receiving. Basically, these requirements include the module transporter, a prime mover, handling set, access kit, and appropriate convoy support at the facility.

Installation of the module into the orbiter cargo bay will be accomplished by hoisting the module above the orbiter and lowering it into position. The attitude of the module must be maintained parallel to the rails in the cargo bay. The module will be lowered onto the rails, and the adapter between the orbiter crew compartment hatch and the forward docking port will be installed. The module will be aligned in the cargo bay to optimize the c.g. location. After the adapter is installed, the tie-downs along the rails will be secured.

Umbilical connections between the orbiter and module will be connected. A leak check of the docking ports will be accomplished at both the module hatch and the orbiter hatch.

4.2.5 MOVE TO PAD AND LOAD TIME-CRITICAL CARGO AND HIGH-PRESSURE GASES

After the orbiter is mated to the booster and integrated tests are completed, the shuttle vehicle, with the cargo module in the cargo bay of the orbiter, is transported to the launch pad by the crawler-transporter.

Prelaunch activities at the launch pad for the cargo module include the loading of time-critical cargo and high-pressure gases.

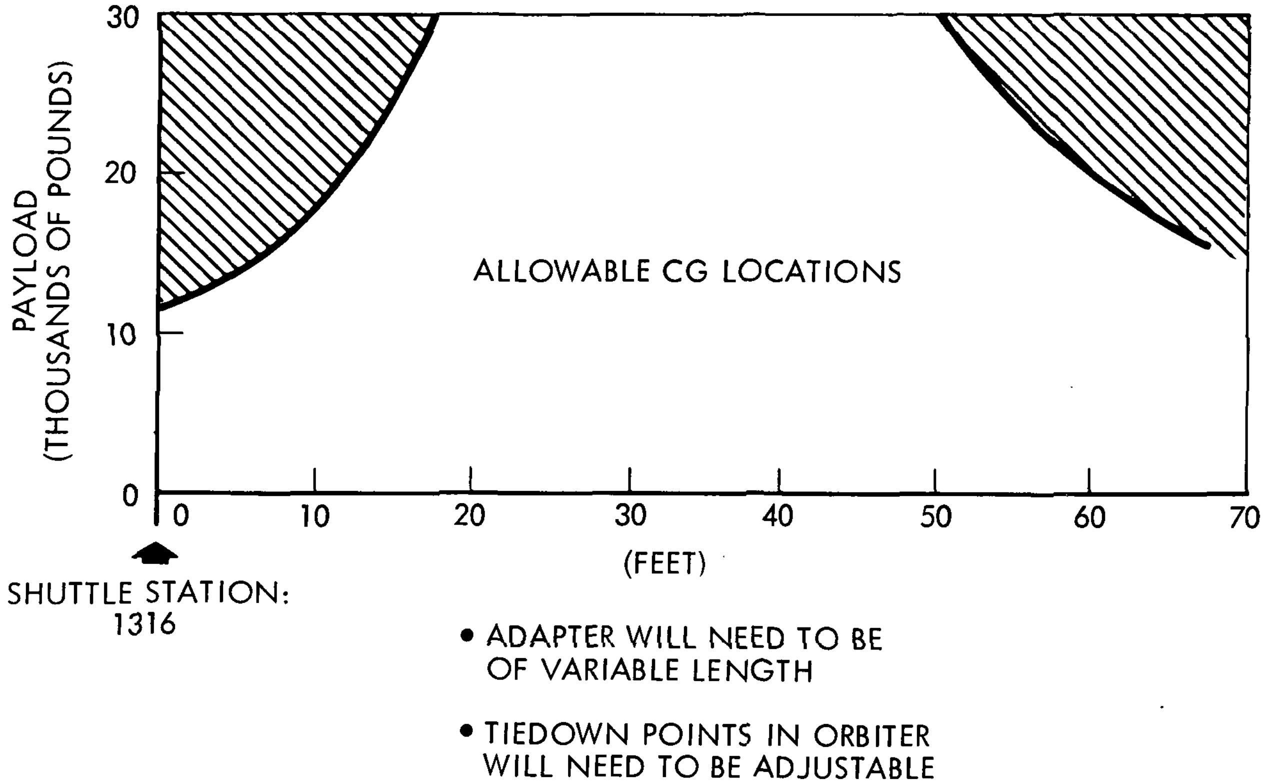


Figure 4.2-3. Orbiter Center-of-Gravity Limitations on Payload

4.2.6 DEFINITION OF FACILITY REQUIREMENTS

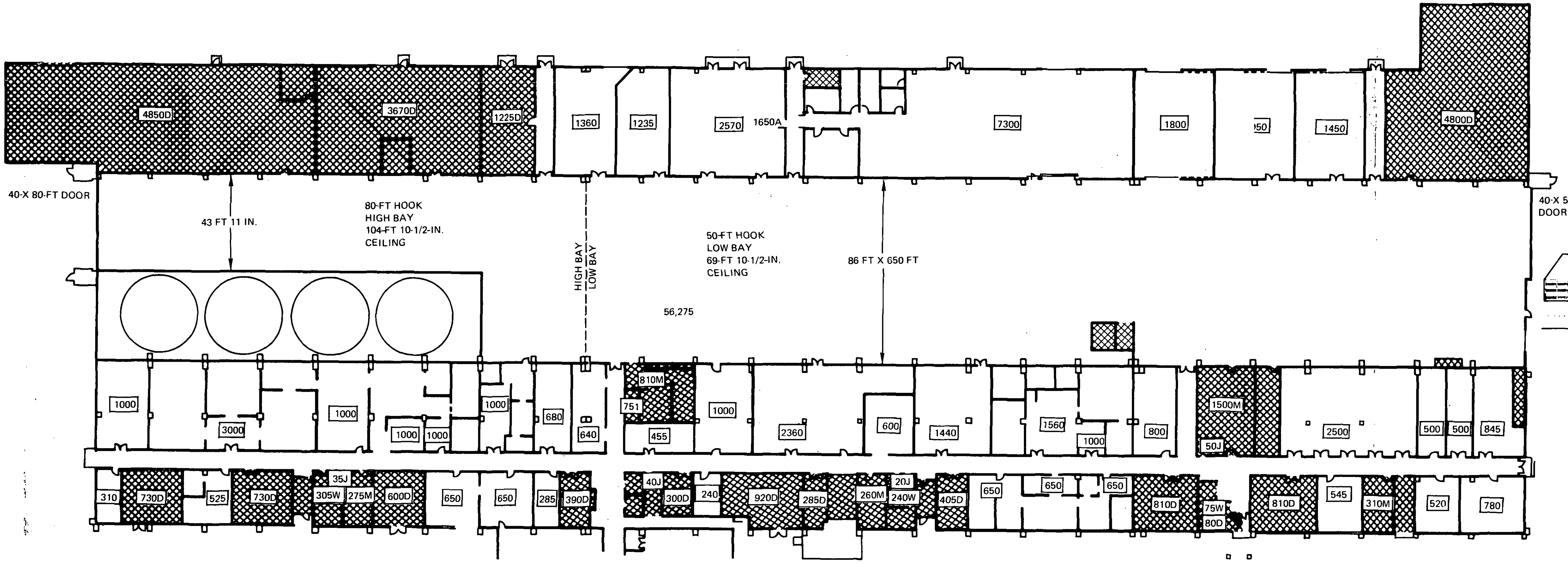
The cargo module processing has been based upon maximum utilization of existing KSC facilities with minimum modifications. A considerably large factor in facility use is dictated by space station program and shuttle vehicle plans as defined by Phase B documentation.

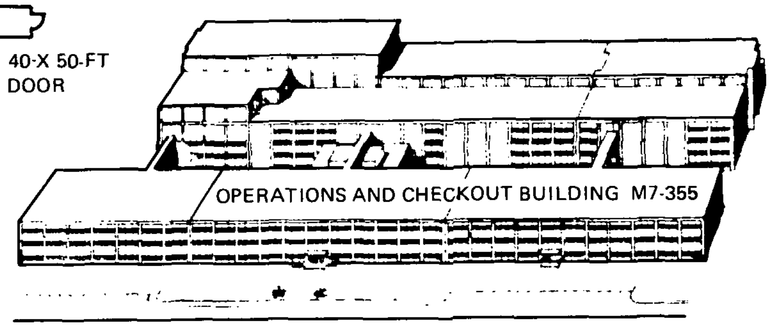
4.2.6.1 Receiving/Recovery Area

The CM could be delivered to the existing skid strip at KSC or the shuttle recovery field. The CM will be delivered by aircraft such as the Guppy, and no special requirements will be specifically levied for the CM.

4.2.6.2 Manned Spacecraft Operations Building (MSOB)

The MSOB contains office space, systems laboratories, ACE-spacecraft station, astronaut quarters, and a test bay area as shown in Figure 4.2-4.





LEGEND:

SYMBOL	FACILITY
C	COMMUNICATIONS
D	MECHANICAL
J	JANITORIAL CLOSET
K	CLOSET
M	MEN'S REST ROOM
W	WOMEN'S REST ROOM
(crosshatch)	SQUARE FEET
	SERVICE AREAS
	UNASSIGNED

Figure 4.2-4. Space Utilization Operations and Checkout Building

System laboratories will be utilized as required to checkout, service, troubleshoot, and repair subsystems or subsystem components. The existing laboratories include a battery laboratory, communications laboratory, S/C instrumentation (site) laboratory, guidance and control laboratory, biomedical laboratory, malfunction analysis laboratory, X-ray laboratory, and a materials testing laboratory. The specific support requirements for these laboratories will be defined at a later date.

The ACE-S/C system includes six control rooms, six computer rooms, a signal distribution room, and a data room. Each control room contains a test conductor console and system consoles. The consoles contain the system status displays and control functions of the S/C or site under test. Each computer room contains two CDC 160G computers and the supporting hardware for the operation of the ACE station. The signal distribution room has the capability, through patching, of selecting any one of 10 test areas and connecting it to any one of the six computer rooms and to any one of the six control rooms. The data room contains the facilities for the review and storage of data.

Assembly and Test Area

The assembly and test area is 86 feet wide and 650 feet long. One-third of this area has a crane hook height of 85 feet, and the remaining two-thirds has a hook height of 50 feet. Each of the three bridge cranes in the assembly and test areas has a capacity of 27 tons. Space is provided for two altitude chambers and two integrated systems test stands. Rising panel doors allow the CM to be moved in and out of the building in either the vertical or horizontal position.

Integrated Test Stand

The integrated test stand (Figure 4.2-5) consists of a steel structure with fixed and movable platforms that provide access to the exterior of the spacecraft. The stand is located between columns 1 and 4, adjacent to the north wall of the Assembly and Test Area of the MSO Building.

The stand is approximately 39 feet wide by 76 feet long. The column foundations are located on elevation minus 12 feet. A fixed platform is located at elevation zero, which is the main floor of the area.

The stand is divided into two areas. Each area has three movable platforms, positioned by a hoist system. Platform 1 may be located between elevations +10 feet and +20 feet; platform 2 may be located between elevations +25 and +35 feet; platform 3 may be located between elevation +40 feet and +45 feet.

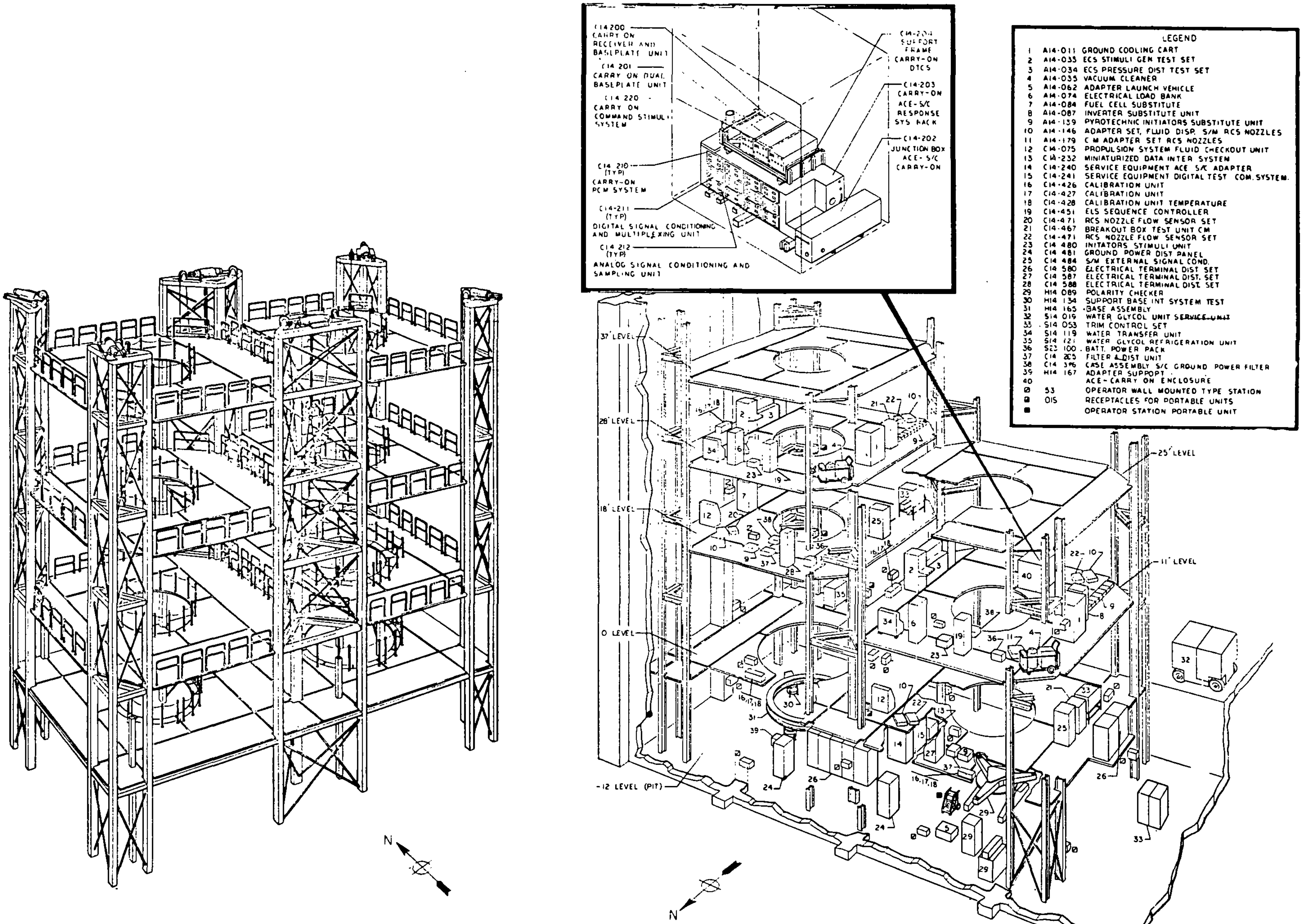


Figure 4.2-5. Spacecraft Integrated Test Stands, Apollo GSE Locations and Communications Configuration

In the east area, the fixed platform has a clear circular opening of 21 feet. Hinged sections lift to give a maximum opening of 23 feet 8 inches. Platforms 1, 2, and 3 each have an opening of 15 feet.

Apollo Altitude Simulation System.

The two altitude chambers (Figure 4.2-6) in the MSO building are designed to support various pressure and simulated altitude tests of spacecraft systems. Each chamber is capable of simulating an altitude of 250,000 feet within 1 hour and returning to sea level in 16 to 30 minutes under normal operation or 2 minutes under emergency conditions. There is no planned use of the altitude chambers; however, they are available for contingency use to validate the total CM as a pressure volume as a result of modification or repair from unexpected problems such as meteoroid impact.

Electrical Power and Distribution

Electric power distribution to the integrated test stand and the altitude chambers is an integral part of the MSO building power distribution system. In this description, only those parts of the system involved in distribution to the integrated test stand and the altitude chambers will be described.

Sixty-cycle industrial power at 13.2 kilovolts (kv) is supplied to substations in and around the MSO building. Power to the integrated test stands and the altitude chambers is supplied by substations D, E, J, and Z. Substations D and E supply power at 480-volts/277-volts and substations J and Z supply power at 208 volts/120-volts. A switching provision in each of these substations allows power to be supplied from one of two feeders. This provides an alternate source of power should one feeder fail. Emergency power could be made available by connecting portable generator units to the connections provided for this in the substations.

Communications.

Communication is provided by the RF operational intercommunication system (OIS). This system provides voice communication between stations in the MSO building and can be interfaced with other audio systems in the Cape and KSC areas.

The RF OIS system is a radio frequency, single sideband, multiplex system providing 112 separate communication channels. Operating channels are dial-selected at each station. Each station has the capability of operating on any channel and there is no limit to the number of stations that can operate at one time on a single channel. One channel is provided to give selected stations access to the operational paging system (OPS).

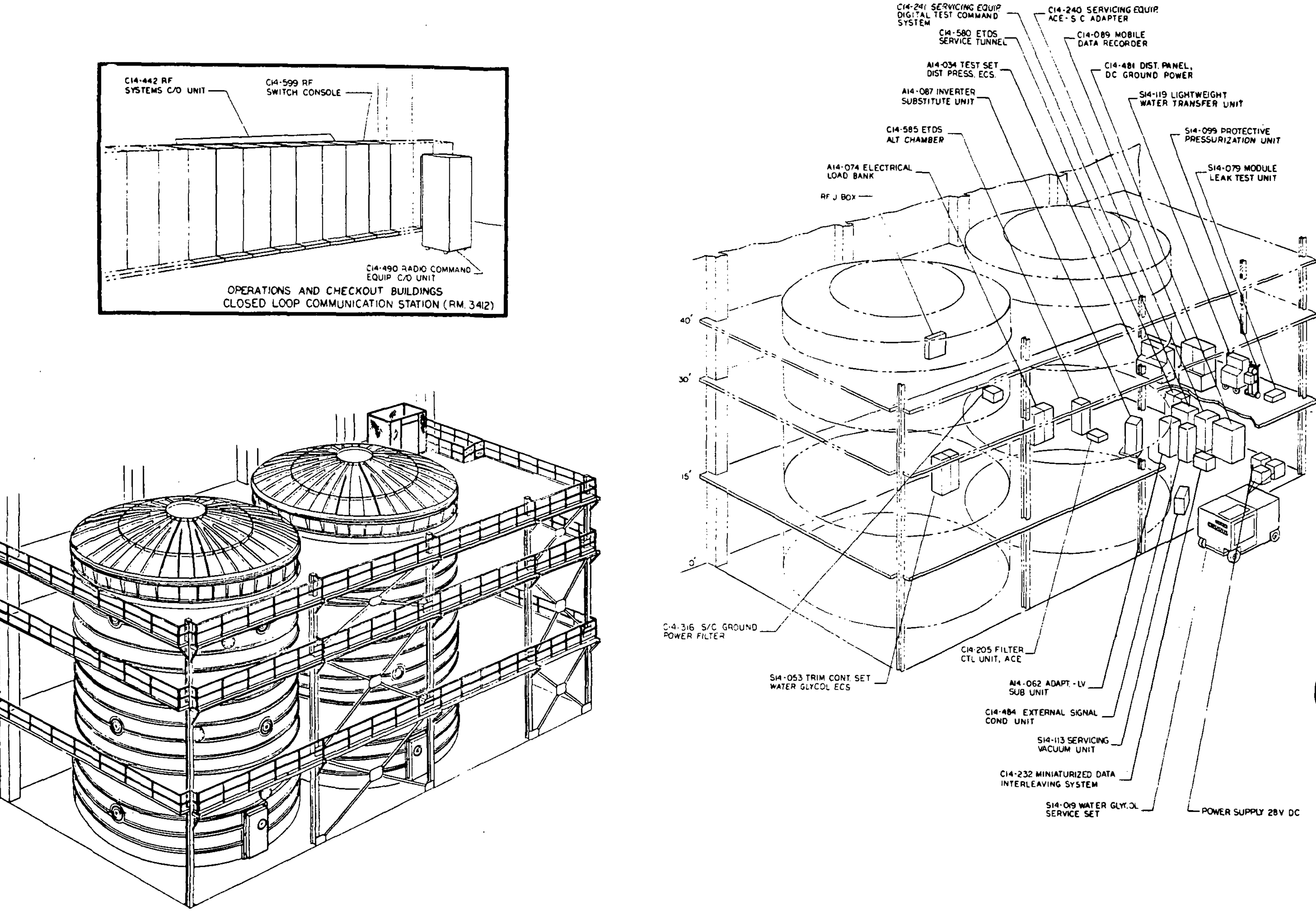


Figure 4.2-6. Spacecraft Altitude Chambers, Existing Apollo GSE Locations

Operator stations in the altitude chamber area are hazard-proof units. Stations in the control rooms are of the rack-mounted type.

Television.

An operational television (OTV) system is provided for spacecraft checkout operations and interconnects with the system in the fluid test area and the documentation and briefing system in the MSO Building.

Checkout operations in the altitude chambers have OTV coverage. Monitors are provided in the spacecraft checkout rooms and the altitude chamber control room. The cameras may be remotely controlled from the altitude chamber control room.

Control of the system originates in the ACE-S/C TV control room, which contains the necessary equipment for control, testing, distribution, and processing of the TV signals.

The S/C control rooms are the control centers for the S/C checkout. The OTV system provides these rooms with television coverage of the checkout operations. The two S/C control rooms each have nine 21-inch monitors and one dual 8-inch monitor. The altitude chamber control room contains six 21-inch monitors and two camera control units with pan/tilt zoom controls.

Cameras assigned to the altitude chambers are hazard-proof and capable of remote control. There are two cameras in each chamber, one for general surveillance and one in the airlock for viewing personnel therein.

Timing System

A subcentral timing station is located in the MSO Building. There is a propagation time delay between the central timing station, located in the Central Instrumentation Facility (CIF) Building, and the subcentral timing station. This delay is compensated for by the subcentral timing station. Timing signal distribution is facilitated by cable between major KSC locations. This cable minimizes interferences and improves mechanical integrity.

Timing terminal units are supplied to the rack-mounted equipment areas of the using activity from which the individual instrumentation media are energized. Modular design is used to facilitate expected expansion.

Building Services Area

Air-conditioning, vacuum pump, spacecraft mechanical shop, and other building service rooms are located in the south wing of the building.

Ground-cooling carts will be installed outside of the building, on the east side, to provide fluid cooling for the MSV. The existing bridge cranes will be used to install the integrated stand decks, install GSE, and to support crew/cargo module checkout with the MSV.

No facility modifications have been identified for the CM over and above those previously defined for MSV operations. Because the CM interfaces the MSV or GSE, all operational requirements will be provided by either the MSV or by GSE end-items, and existing facility provisions are usable without modification.

4.2.6.3 Supply, Shipping, and Receiving Building (M7-505)

This building is located in the KSC Industrial Area on 2nd Street between D and E Avenues.

This building contains a shipping, receiving, processing, and controlled storage area. Ready storage space for items requiring controlled environment to prevent deterioration is available. Also, storage area for ground support equipment and spare parts is located within the building. Shop facilities presently exist within the building for ground service equipment, cleaning, maintenance, and plastic shops.

The building consists of two basic areas that are suitable for handling up-and down-cargo for the CM operations. It has been estimated that approximately 40,000 square feet are required to set up the cargo ground-handling facility. This building contains over 50,000 square feet and is physically divided such that separation of cargo plus an integration or packaging area are readily laid out. Figure 4.2-7 illustrates the basic floor plan of the buildings; however, there are presently wire mesh enclosures separating various activities that are set up for the Apollo program. The south end of the east wing is a high-bay structure that can adequately facilitate two CM at one time in the event one CM had to be loaded and one unloaded simultaneously. A 5-ton bridge crane services the high bay and could be used to handle the loading device or heavy components or cargo.

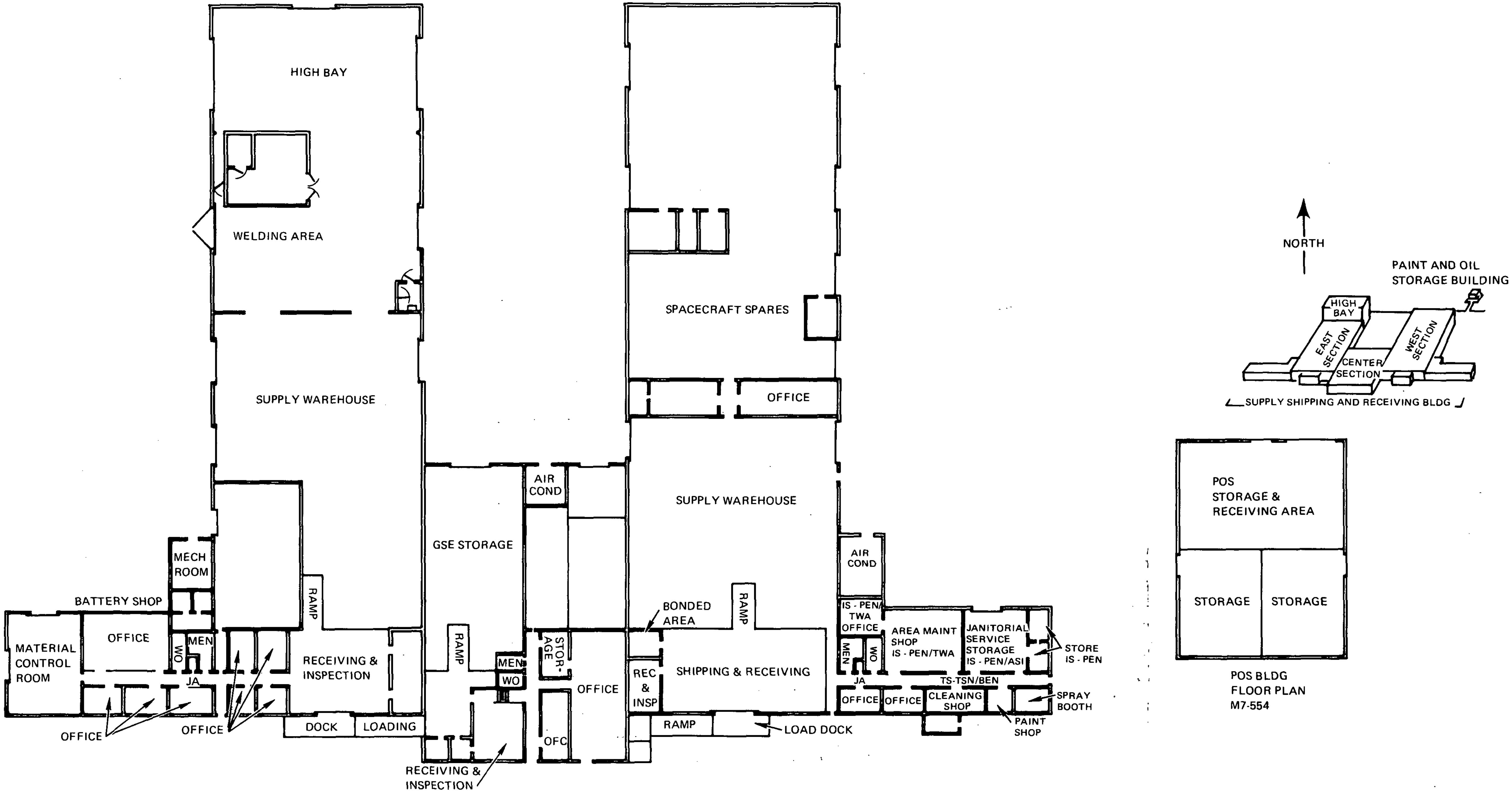


Figure 4.2-7. Launch Operations-Space Utilization (Buildings M7-505 and M7-554)

The high bay has 30- by 40-foot lift panel doors on both the east and west side, which will allow the CM to be placed in the building from either direction or to pass through the building.

Refrigeration and freezer storage space will be required for the CM; however, it is not mandatory that it be located in this building, because this type of cargo is not loaded into the CM until the countdown operations at the launch pad. For the purpose of this study, it is proposed that the storage of all cargo, including the time-critical cargo, be provided for in this building.

Specific ground cargo-handling layouts and planning have not been accomplished as a part of this study; and, therefore, the floor plan does not depict the flow of up- and down-cargo. A typical flow utilizing this building and the MSOB is shown in Figure 4.2-8.

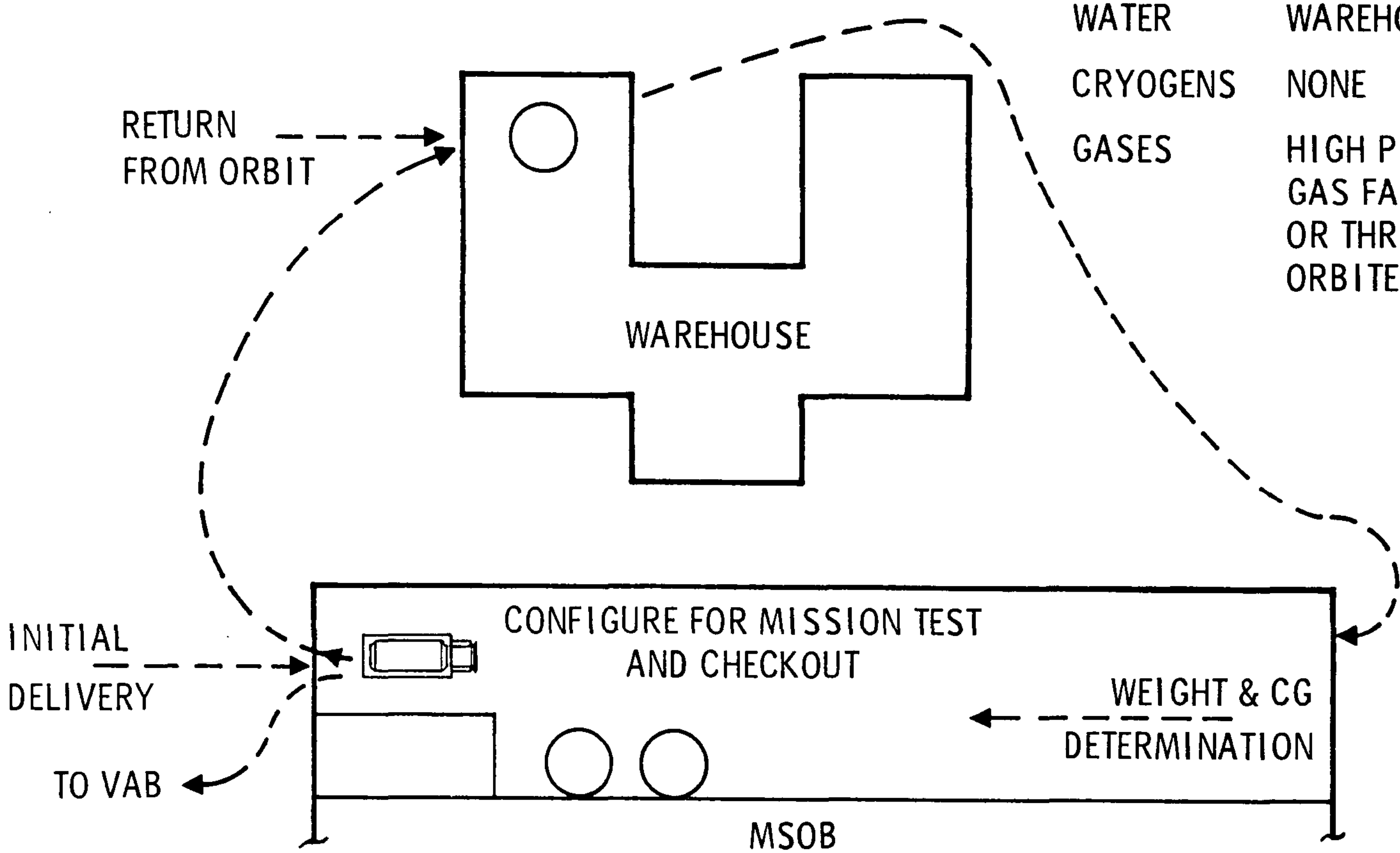
The facility modifications that are required in this building are as follows:

1. Remove the wire mesh area dividers and relocate them as determined necessary for security of the cargo as established by the cargo-handling layouts and plan.
2. Remove and relocate the shop requipment presently installed in the building to preclude cargo contamination.
3. Fabricate a refrigerator and freezer storage facility. This might be located within the existing concrete block enclosure in the east wing adjacent to the high bay as illustrated in the figure.

4.2.6.4 Cryogenic Test Buildings (M-1412, M-1410)

Two buildings in the fluid test area, located between Ninth and Tenth Streets in the KSC industrial area, are designed Cryogenic Test Buildings 1 and 2. Cryogenic Test Building 1 is located on G Avenue, and Cryogenic Test Building 2 is on F Avenue (Figure 4.2-9). This description is included for information only, because planning changed from cryogenic tanks for resupply.

Each building consists of a single test cell having an overhead bridge crane with a 20,000-pound capacity and a 45-foot hook height. The four walls of the test cells have 40-foot-high vertical lift doors for moving vehicles in and out. Each cell has a deluge fire protection system and a hazardous gas detection and alarm system.



FLUID LOADING

TYPE	LOADING
WATER	WAREHOUSE
CRYOGENS	NONE
GASES	HIGH PRESSURE GAS FACILITY OR THROUGH ORBITER

Figure 4.2-8. Cargo Module Loading Operations

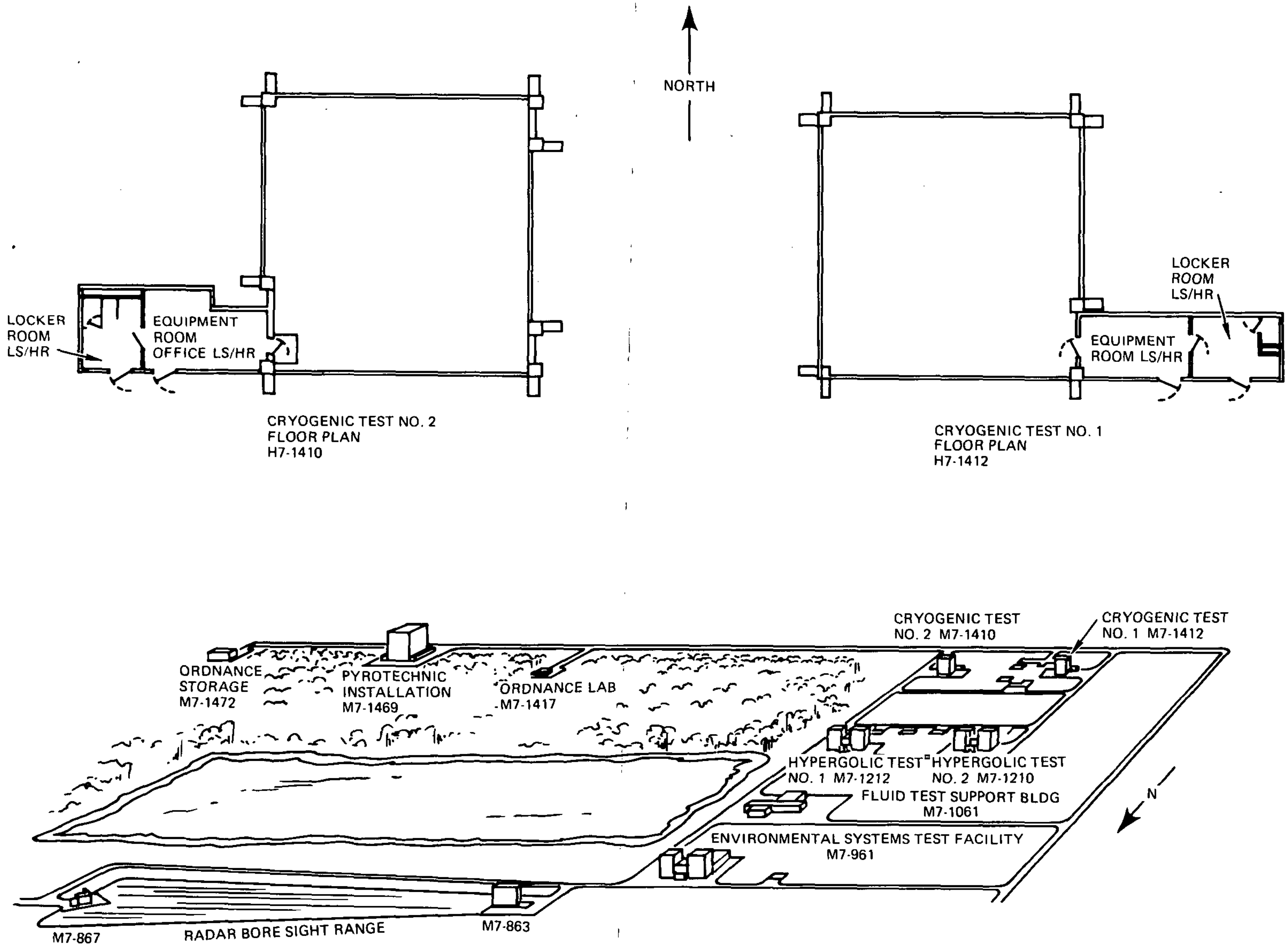


Figure 4.2-9. Launch Operations-Space Utilization (Cryogenic Buildings)

The configuration of the buildings for Apollo program support includes the capability to load dewars of LO_2 in Cryogenic Building 1, and LH_2 in Cryogenic Building 2. If required, typical payloads could have the LO_2 and LN_2 loaded in one building and then be moved to the other building for LH_2 and LHe to keep modifications to a minimum. This was a former requirement of the CM but was deleted by changes to the MSS subsystem design.

4.2.6.5 Maintenance and Checkout Facility

Phase B shuttle information indicates an addition to the north side of the existing VAB for orbiter vehicle operations. This addition tentatively has been designated the maintenance and checkout facility (MCF). No specific requirement for the use of this facility has been identified for the CM.

4.2.6.6 Vertical Assembly Building - VAB

The selection of horizontal processing a vehicle horizontally rather than vertically would make no difference. Vertical loading the CM into the cargo bay would require the use of one of the existing bridge cranes but would not require modifications. The CM would impose some impact to the existing VAB under the concept of loading the resupply gases prior to loading the module into the orbiter.

4.2.6.7 Launcher/Umbilical Tower (LUT)

Ingress and egress of passengers to the CM is required for three operational situations: on the ground, on the pad, and in space.

On the ground, during prelaunch operations prior to loading into the orbiter, the ingress and egress is made possible by access stands to the docking ports. The operations analysis has considered the position of the CM for optimum personnel acclimation. That is, loading is done in the vertical to allow normal standing on the transverse floors, and checkout is accomplished in the horizontal to ensure that the passengers are seated in the normal upright position for on-orbit flight simulations.

On the pad, or any time after loading the CM into the cargo bay of the orbiter, ingress and egress may be through the orbiter using the main hatch and docking port interface. In addition to normal ingress and egress by the passengers and service crewman, two other considerations must be taken into account: emergency egress and loading provisions for time critical cargo. It should be reiterated that the CM will not be occupied during boost and entry.

Various study concepts for shuttle positioning include new configurations of LUT's, orbiter next to tower, orbiter away from the tower relative to the booster, booster set on elevated tie-down, and booster projecting into the base of the launcher.

For this study, the booster nearest the tower concept has been selected for the baseline, and the concept of orbiter nearest the tower also has been studied. The vertical position of the cargo bay relative to tower elevations and actually the distance between the tower and the cargo bay have not been defined dimensionally. These details must be determined during a later phase of design and development. Figure 1.4-8 shows the relative positions of the shuttle to the LUT and the service arm required by the CM relative to the cargo bay and to the LUT.

4.2.6.8 Pad

Launch pad requirements for shuttle include the integrated CM requirements, because the CM interface is with the shuttle vehicle. These requirements include environmental air, purges, OIS, OTV, etc.

Passenger missions require the availability of an emergency escape system and protective facility.

The existing blast room is adequate for personnel protection; however, a means of getting from the LUT to the blast room must be provided.

4.2.6.9 Recovery Area

The recovery area will be the landing site for the orbiter. No special facility is required for CM operations, because all support is planned to be provided by ground support equipment. Support activities includes passenger and time-critical cargo removal.

4.2.6.10 Safing Area

The safing area must have the capability to detank cryogenics and purge the tanks.

4.2.7 DEFINITION OF GSE REQUIREMENTS

For the purpose of this study, ground support equipment has been categorized into three classifications:

1. Handling GSE. Handling GSE will include transporters, dollies, rings, slings, environmental protection, personnel ingress/egress devices, platforms, and other such items.

2. Checkout GSE. Checkout GSE will include equipment for verifying systems by physical and functional test using scientific instrumentation.

3. Support GSE. Support GSE will include all auxiliary and servicing equipment that does not lie in either of the other two categories. This would include ground cooling, tugs or tractors, preservation kits, and tie-down kits.

A vertical transporter similar to that shown in Figure 4.2-10 is required for use during noncritical cargo-loading operations.

Use of the existing Apollo CSM vertical transporter would require a simple adapter to be compatible with the CM diameter and to allow vertical clearance for the conical end of the module.

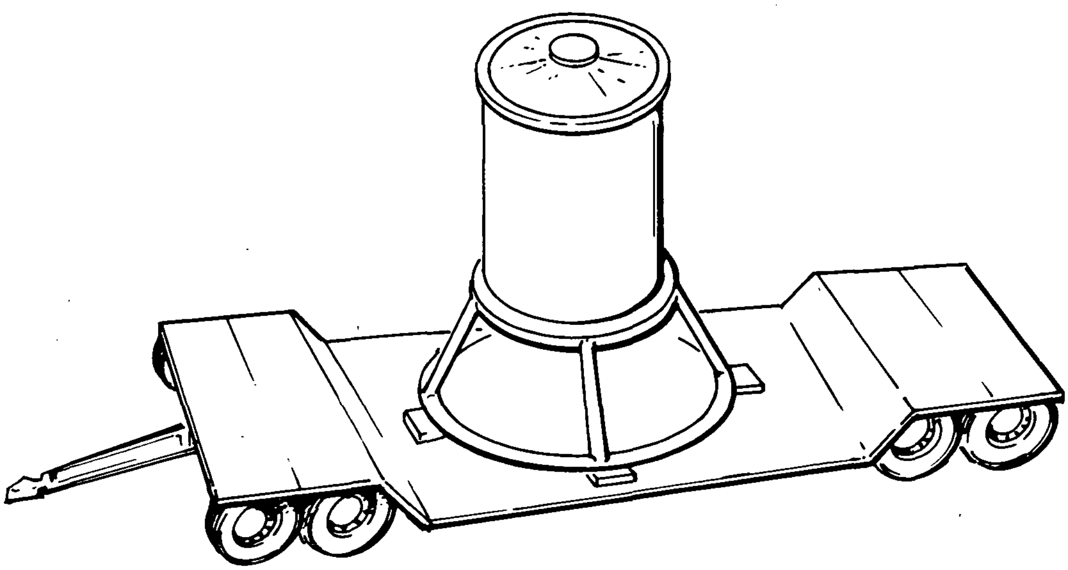


Figure 4.2-10. CM Vertical Transporter and Transporter Adapter Frame

Fore and aft handling rings as depicted in Figure 4.2-11 will facilitate all ground-handling operations. These rings must be segmented to allow ease of handling when not on the module and facilitate their removal after the CM is loaded in the orbiter. A ring segment handling sling will be required for this purpose as shown in Figure 4.2-12.

Rotation of the CM from horizontal to vertical or from vertical to horizontal will require a handling sling as depicted in Figure 4.2-13.

Load cells for performing weight and c.g. determination will be required. Equipment similar to the H14-041, 30,000-pound-weight kit used on the Apollo program would be satisfactory. Other Apollo equipment that would be similar to that required for space station weight and balance include the following:

H15-154-0001	Dc digital indicator
H14-177-	Horizontal S/C weight and balance set
H14-178	W/B load relieving device

4.2.8 SHUTTLE INTERFACES

Because the module is self-sufficient, the interface to the shuttle is kept to a minimum. The only interfaces required are structural, power, and communication.

The structural interface consists of three hard points or load distribution points. The forward and aft load is reacted at the forward docking ring, which interfaces with the active docking ring of the shuttle.

This interface has tension, compression, and shear capability.

The lateral loads are distributed to the shuttle through the two trunnions located on each side of the aft bulkhead. These trunnions interface with shuttle latch mechanisms.

The communication interface consists of communications and monitoring data interconnected with the shuttle through plugs in the docking ring. These plugs must be manually disconnected prior to separation from the shuttle. Conversely, the plugs must be manually connected to reestablish contact with the shuttle when the shuttle docks to remove the cargo module from the space station.

Electrical power is provided to the cargo module through electrical connectors and plugs that interface with the docking ring in the same manner as the communications interface.

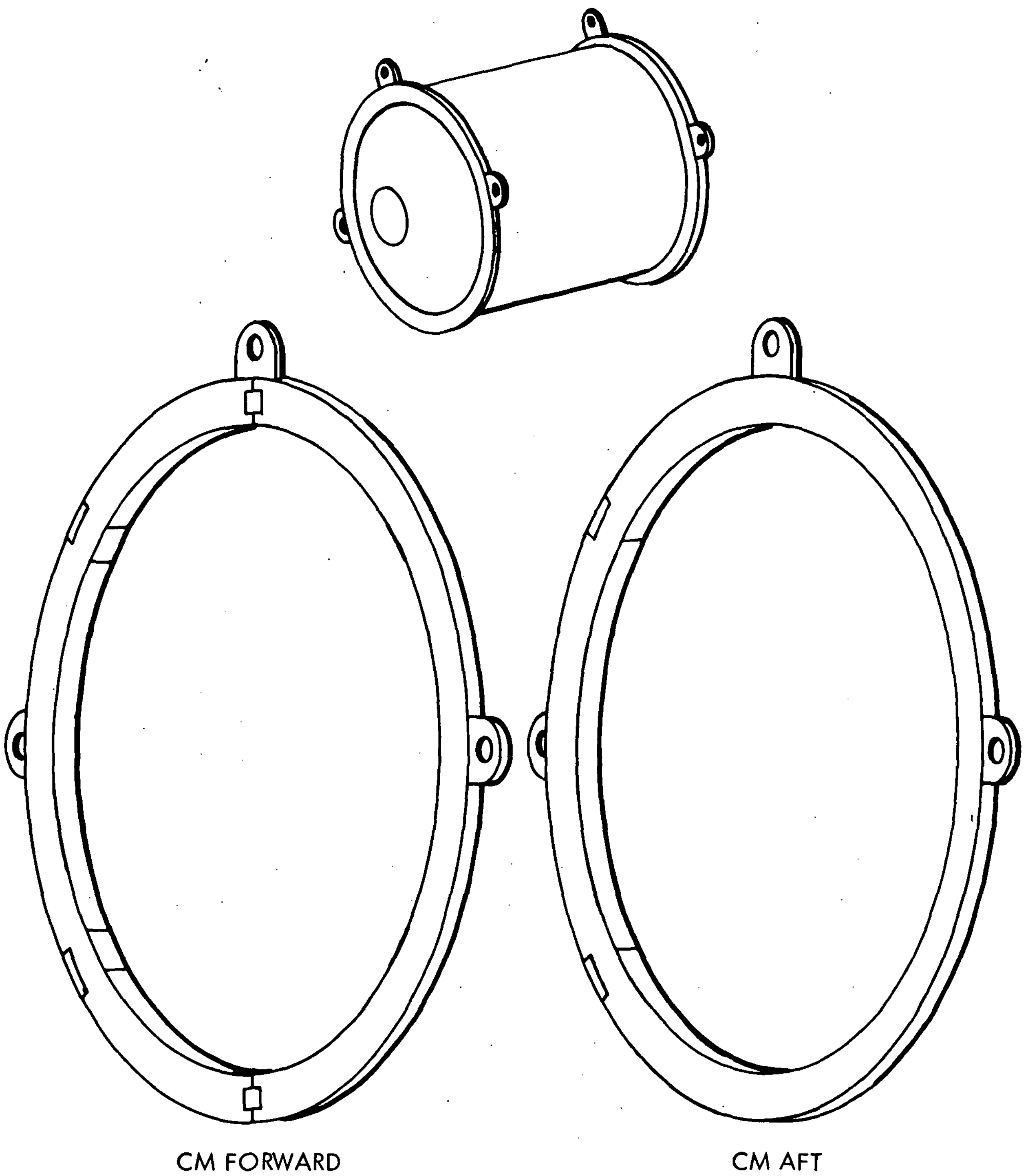


Figure 4.2-11. Forward and Aft Handling Rings

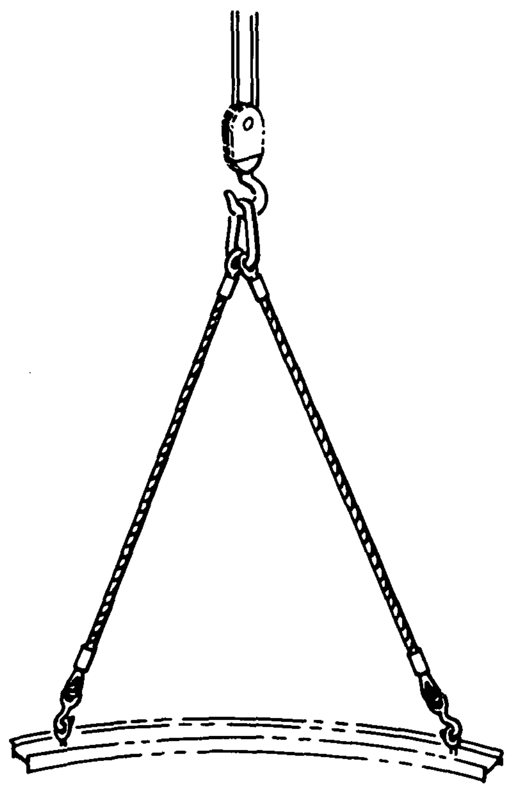


Figure 4.2-12. Ring Segment Handling Sling

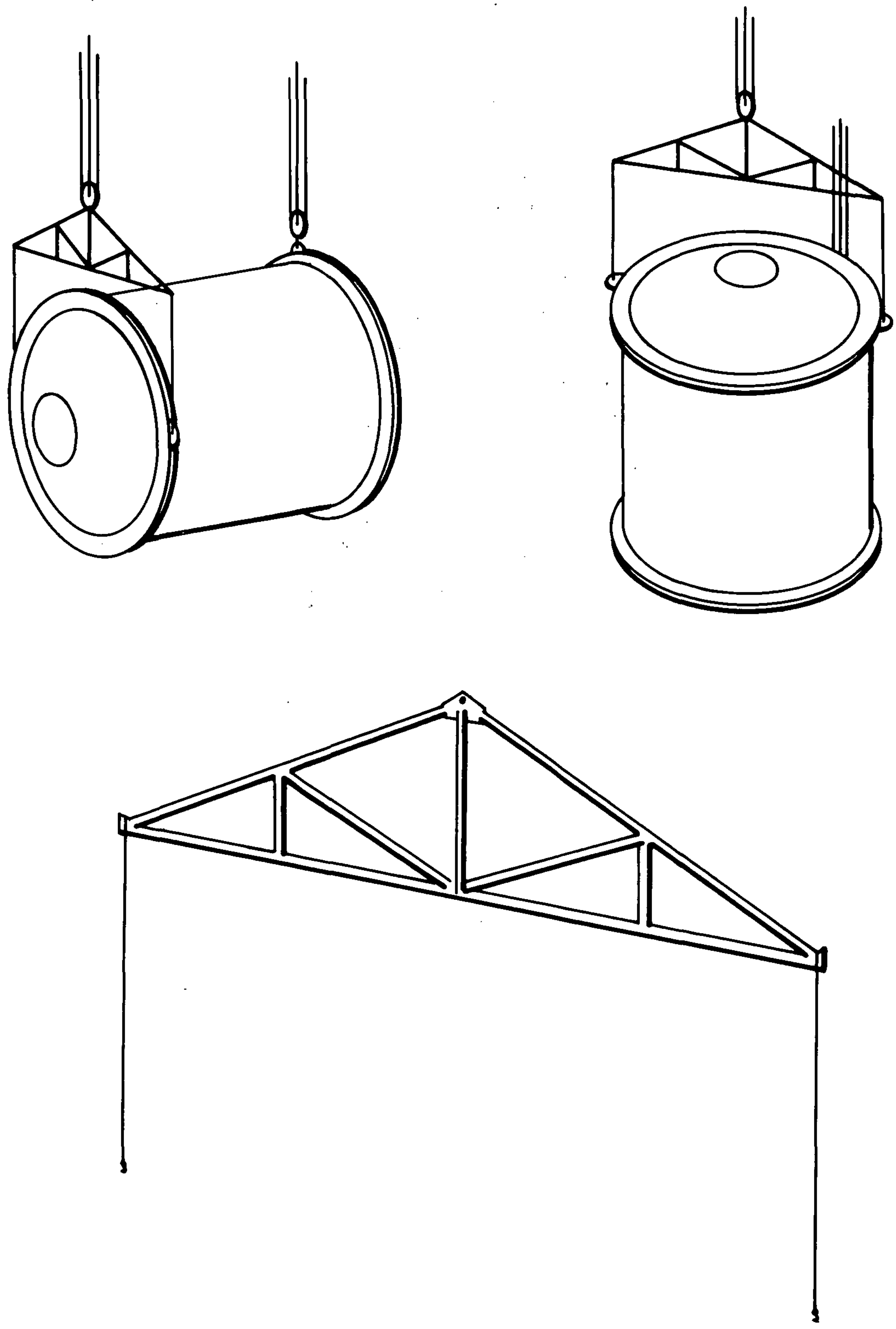


Figure 4.2-13. Cargo Module Handling Sling

4.3 FLOW PLANS

The overall cargo module schedule for operations at KSC in relation to Phase B information for the Space Station program and the Shuttle program is given in Figures 1.2-18, 1.2-20, 1.5-8, and 2.3-1. These figures depict the activation, operations, and mission support schedule for the space station cargo module and the corresponding facility/GSE engineering and activation, deliveries, and operations to support the indicated shuttle orbital flight test program that precedes the space station operations.

This section addresses several flow plans, including the initial receipt or recycle after a major modification or refurbishment, normal prelaunch processing, expedited turnaround, vertical shuttle prelaunch operations, the launch operation, countdown, and recovery. Figure 4.3-1 shows the relationship and sequence of the previously mentioned phases.

The CM will arrive at KSC by air (Guppy). The longitudinal (X-axis) of the CM will be in a horizontal position during shipment and transport to the MSV site (MSOB). The transporter/pallet off-load operation will require specialized handling techniques. The transporter should be a universal design capable of transporting cargo modules and station modules requiring checkout in the MSOB. The transporter should have the capability of providing vernier control in four directions: laterally up to ±5 inches from the centerline and ±4 degrees in pitch, roll, and yaw. The transporter should be capable of lifting the CM from the Guppy and hoisting it to the level of the MSV deck 1 docking port.

For the CM, the transporter must have the following capabilities:

Load capacity	2500 pounds
Length	25 feet*
Pallet width	14.0 feet

*38 feet, 8 inches as a common structure module

The environmental control requirements of the CM during shipment and transfer to the MSOB are:

1. Thermal

2. Humidity - There will be no condensation on equipment. Moisture in area surrounding equipment should not exceed 20 grains per pound of air when equipment is not in use and stowed.

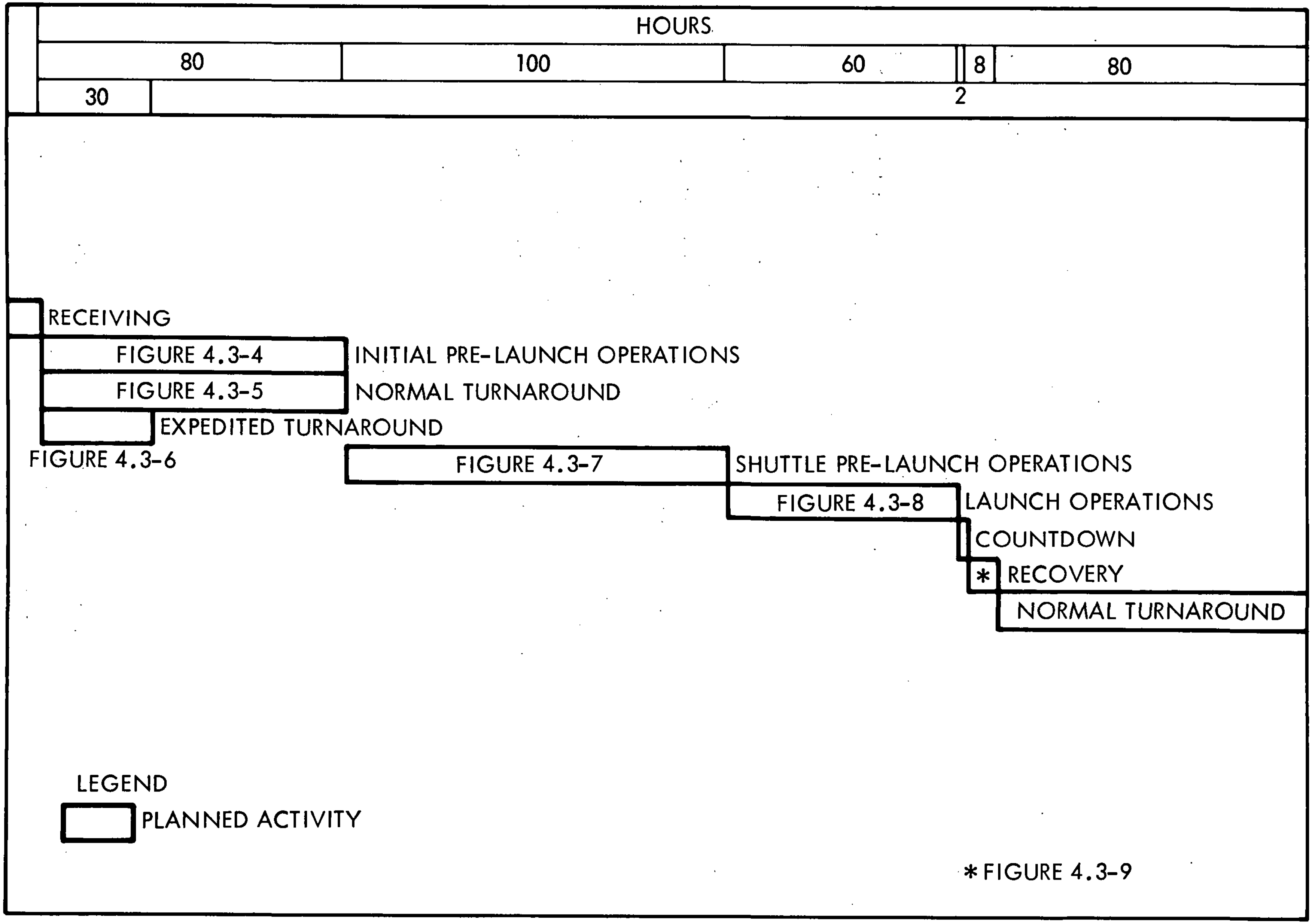


Figure 4.3-1. Cargo Module Processing Plan Definition

3. Contamination. CM instruments must be assembled and handled at all times in a clean atmosphere. Shipment should be in a conveyance that can supply clean dry air at a temperature of 80 F maximum during shipment.

4. Vibration, shock, and acoustic noise. While nonoperative, the equipment shallbe subjected to no more than its design limitations, which are TBD.

A towing (tractor) vehicle will be utilized to tow the transporter from the landing field to the MSOB. Upon arrival at the MSV site (MSOB), a receiving/inspection will be performed to determine any visible intransit damage. All external protective covers will be removed.

The MSV site shall have a minimum area of approximately 1000 square feet in which the CM will be inspected and checked out for flight. The cleanliness requirements to which this area shall be maintained are identified in Technical Order (TO) 00-25-203, Standards and Guidelines for the Design and Operation of Clean Room and Clean Work Station, dated July 1963. (As an alternate, FED-STD-209A, Clean Room and Work Station Requirements, Controlled Environment,may be used.)

An overhead lifting device will be required to assist in removing the protective devices and any special packaging. For the sake of commonality, the capability of the lifting device (or crane) should be such that it also could be used to lift the module itself (25,000 pounds) and move it horizontally in any direction.

The receiving inspection also will require the removal of special packaging and transportation tie-down devices inside the module. The special packaging may include an air-conditioned hood or canopy covering the entire CM and mounted to the shipping pallet. No special tools are required except those supplied as part of the module tool kit.

Following the receiving/inspection, the CM will be moved to the MSV while still on the shipping pallet and transporter.

With the module -X-axis facing the MSV, the CM is raised to the MSV docking port for docking and physical fit-check.

Prior to mating the module with the MSV, an electrical interface verification is required to determine status of the module. Standard checks such as continuity tests, resistance checks, and visual inspection of connections using standard tools are typical of checks to be made at this time. Upon satisfying these checks, the module is docked, power and control cables to MSV are attached, and the module is activated per procedure.

A successful docking of the -X-axis of the CM to the +Z docking port on the MSV will satisfy the mechanical interface between the two units as depicted in Figure 4.3-2.

There is a second mechanical docking interface required between the +X-axis of the CM and the orbiter. However, this interface uses an orbiter docking simulator.

This simulator must be capable of providing electrical power and commands to the CM when attached. Mobility for this docking mechanism simulator is to be provided by the overhead crane.

This portion of the mechanical interface is performed just prior to removal of the CM from the MSV. The simulator will provide the command to the CM to undock from the MSV including the electrical power to actuate the unlocking mechanism. Similarly, signals are sent from the MSV control center to undock from the orbiter (simulator). Having undocked from the MSV, the mechanism is now commanded to unlatch itself from the CM.

The CM subsystems and sensor checkouts will be accomplished utilizing whatever MSV systems are required to be powered-up for the particular test in progress.

Figure 4.3-3 represents a typical schedule for subsystem checkout for a comprehensive prelaunch system verification.

Following a satisfactory checkout, the CM is prepared to cargo loading as described in paragraph 4.2.3.2.

The CM will be transported directly to the shuttle checkout facility for loading into the orbiter at approximately 20 hours prior to rollout to the pad.

Figure 4.3-4 depicts a nominal CM schedule for an initial prelaunch checkout, a prelaunch checkout after storage, or a prelaunch checkout after major modification. Nominally, there are 80 working hours, based on a single shift, 5-day-week operation, between missions.

Figure 4.3-5 depicts a nominal turnaround operation for a CM. The CM is safed, and the O_2 tanks are purged in the shuttle safing area while still loaded in the orbiter. The CM then moves directly to the warehouse where the down-cargo is removed. The CM undergoes an inspection, and any noted anomalies are identified. Cleaning of the interior is accomplished at this time. After the CM is unloaded and cleaned, it is moved to the MSOB for either reconfiguration for the next mission, for troubleshooting problems identified during the mission or during off-loading, or for refurbishment

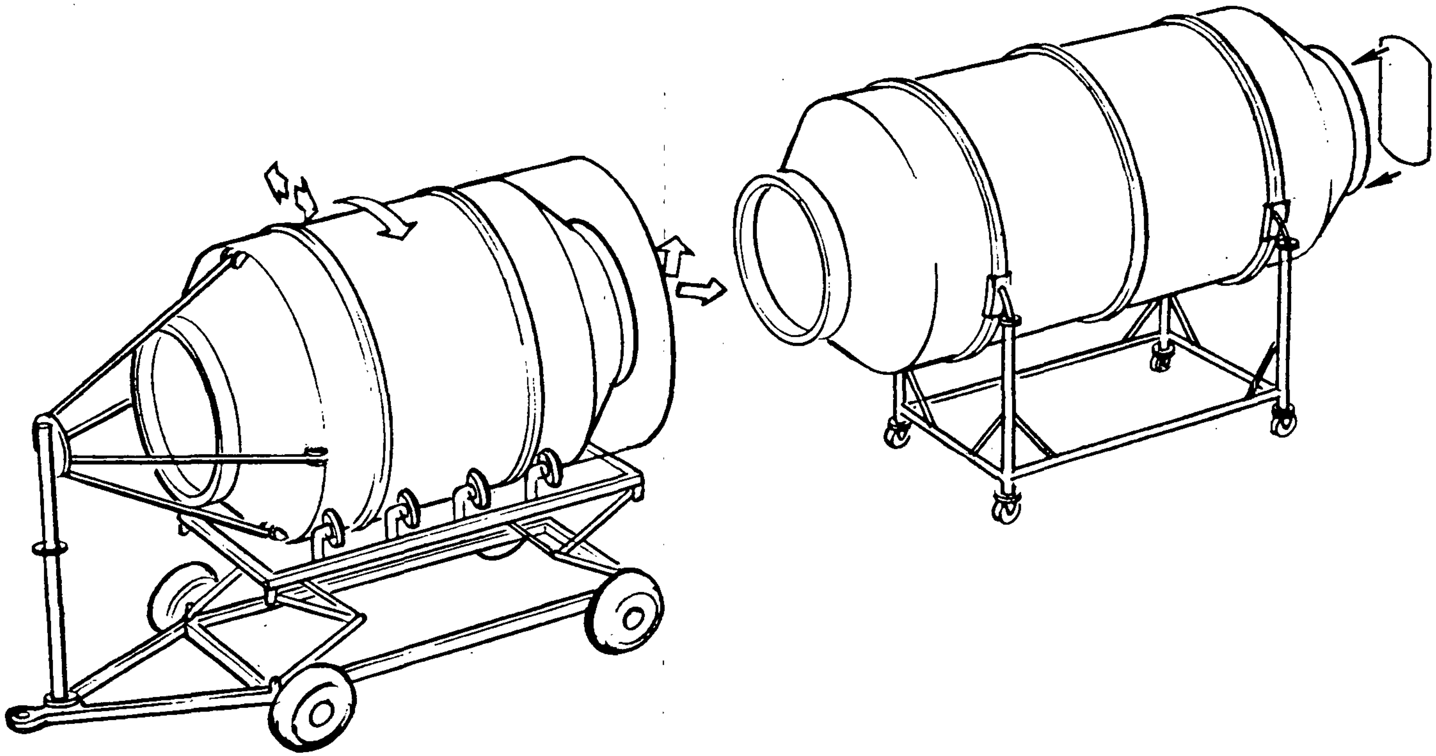


Figure 4.3-2. Cargo Module Mating With MSV

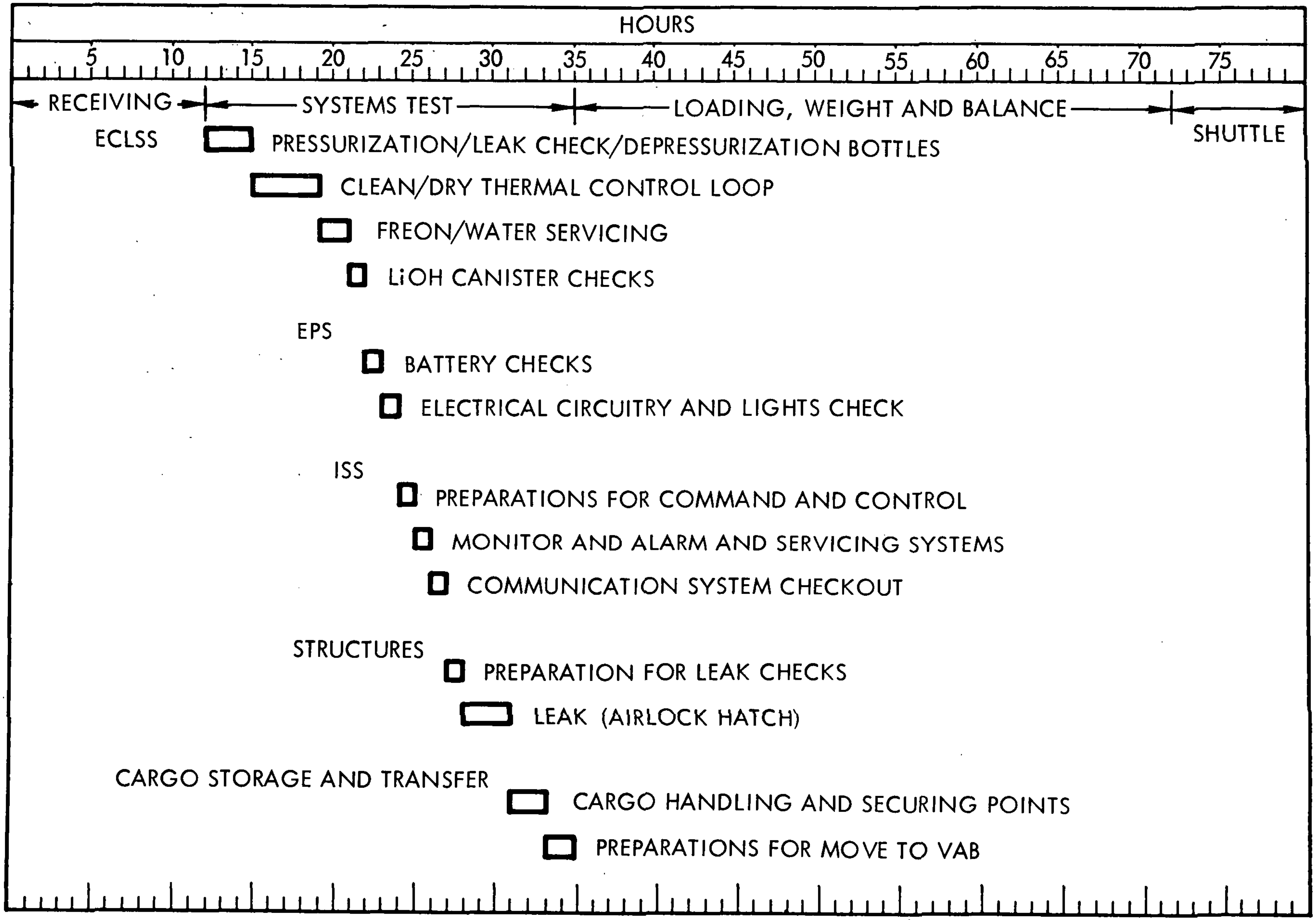


Figure 4.3-3. Cargo Module Systems Verification

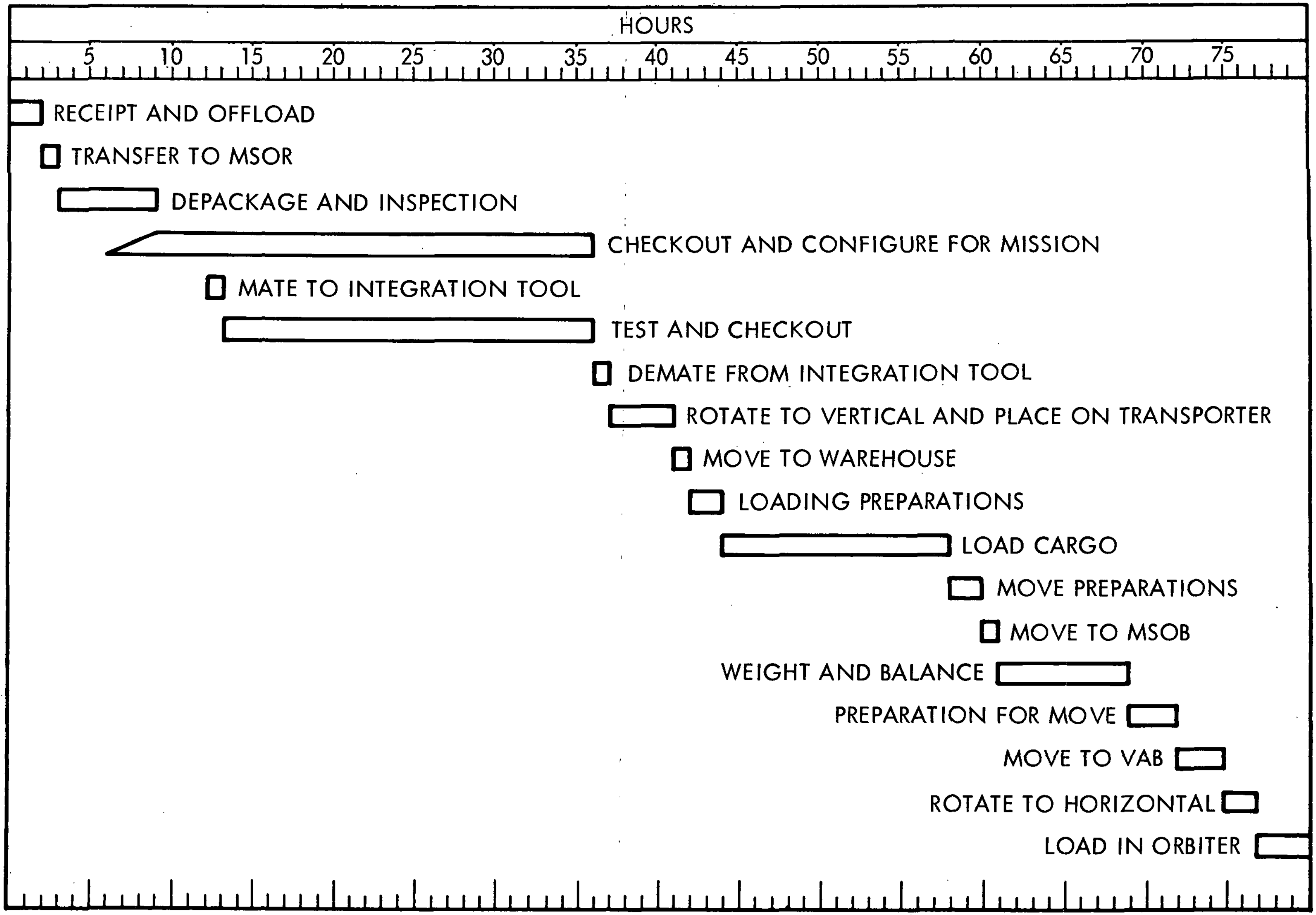


Figure 4.3-4. Cargo Module Initial Receipt and Preparation

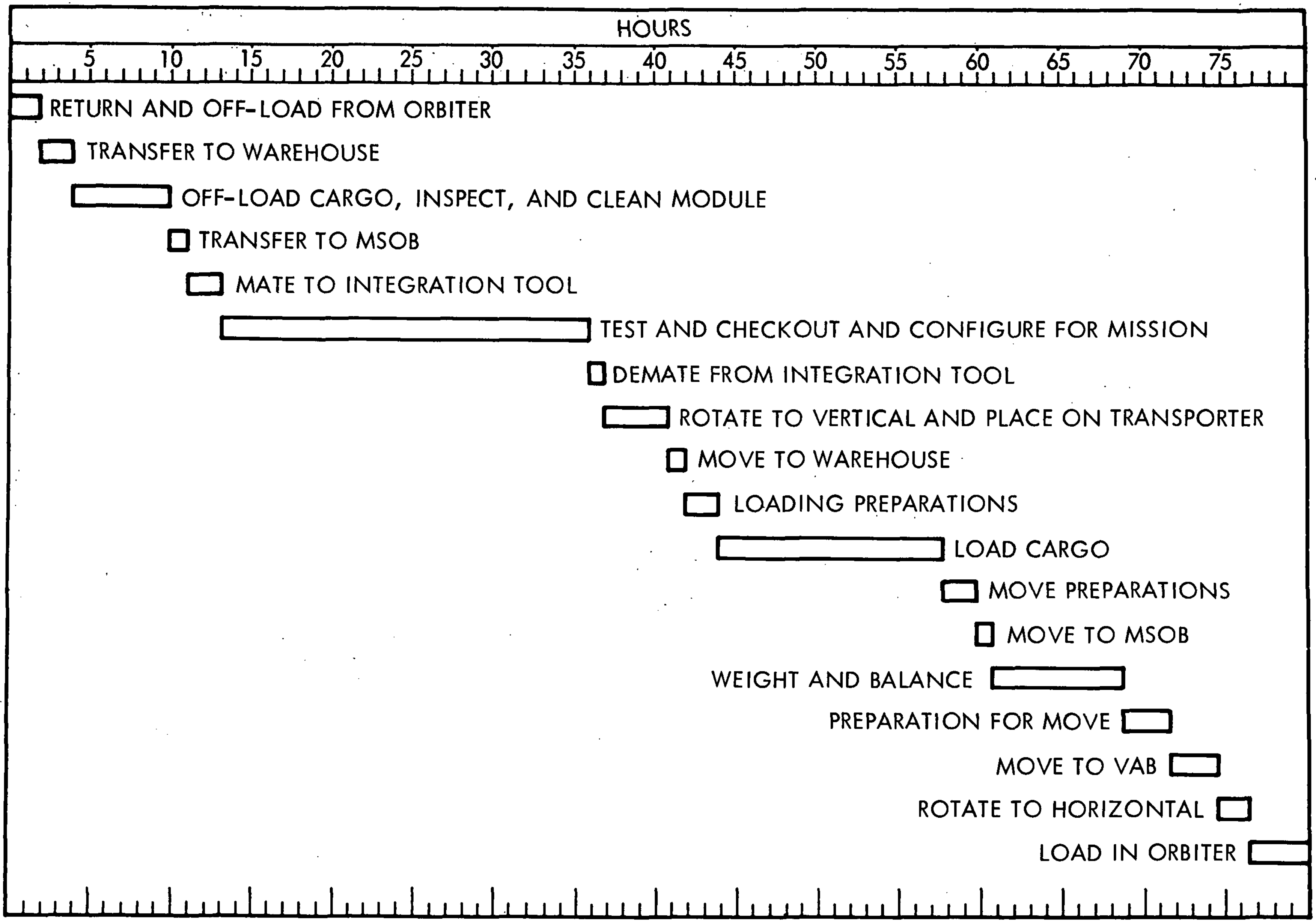


Figure 4.3-5. Cargo Module Normal Prelaunch Turnaround

and standard preventive maintenance activities. Docking to the integration tool and functional checkouts are optional for a normal turnaround, depending upon the individual situation. Ground support equipment will be required to enable systems testing without control from the integration tool.

Operations after the systems checkout are the same for normal preflight as for the initial operations or for preflight after major modifications.

Figure 4.3-6 depicts an expedited prelaunch turnaround. The significant differences are that the up-cargo is loaded immediately after the down-cargo is removed and the CM is cleaned, and there is not system checkout independent of preflight checkouts to be conducted later with the orbiter. This expedited turnaround reduces the ground time by approximately 30 working hours and may be reduced an additional 8 hours if the weight and balance operation could be eliminated.

4.3.1 VERTICAL PRELAUNCH PROCESSING

Figure 4.3-7 depicts a nominal vertical prelaunch processing schedule. During the loading of the CM into the orbiter, there is no access available. The CM will be loaded into the orbiter in the shuttle orbiter bay of the VAB. Orbiter GSE, such as cargo bay adapters, guide rails, cushioning and protective materials, will be installed in the open cargo bay.

The CM will be hoisted above the orbiter and lowered into the cargo bay, maintaining an attitude compatible with that of the orbiter. After the CM is fully lowered, the aft interface is established, and the orbiter retractable cargo retainer and centering device is engaged. This interface is the principal load-bearing surface for the CM during vertical operations. The CM will then be driven forward to soft dock with the deployment mechanism. Minimum checkout is planned for either interface, because these surfaces, seals, and connections were previously checked and verified with master tooling-type GSE. Lifting slings will be removed after both interfaces have been made and verified, and after it is ensured that the orbiter mechanisms are capable of sustaining the cargo module loads.

The crew in the orbiter cockpit will make all necessary checks of subsystem continuity and position indicators. After all checks have been made, the installation GSE is removed from the cargo bay and the bay doors closed. After CM installation operations have been completed, the access workstands will be removed.

CM/orbiter checks will be accomplished in conjunction with the orbiter/booster checkout in the VAB.

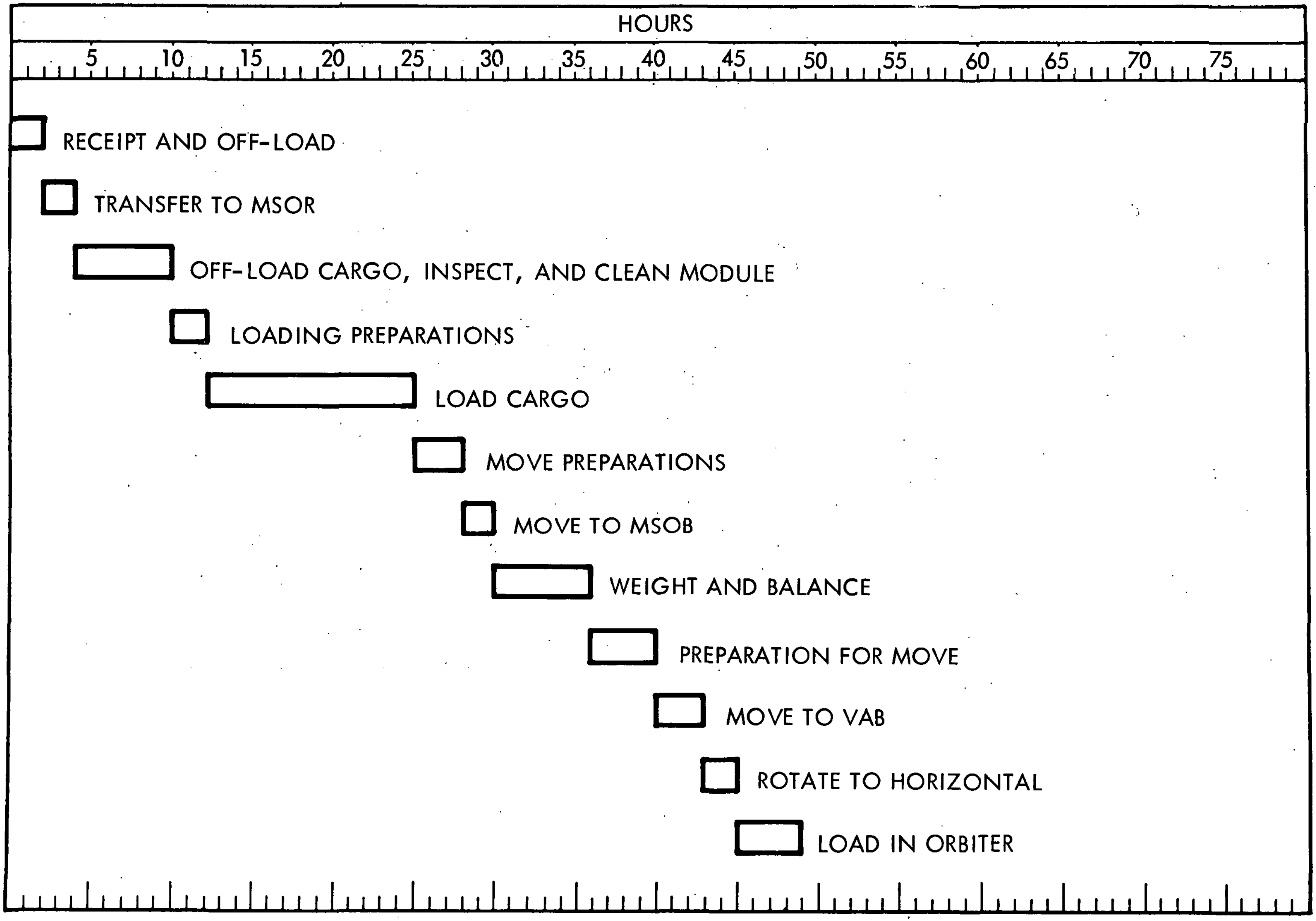


Figure 4.3-6. Cargo Module Expedited Prelaunch Turnaround

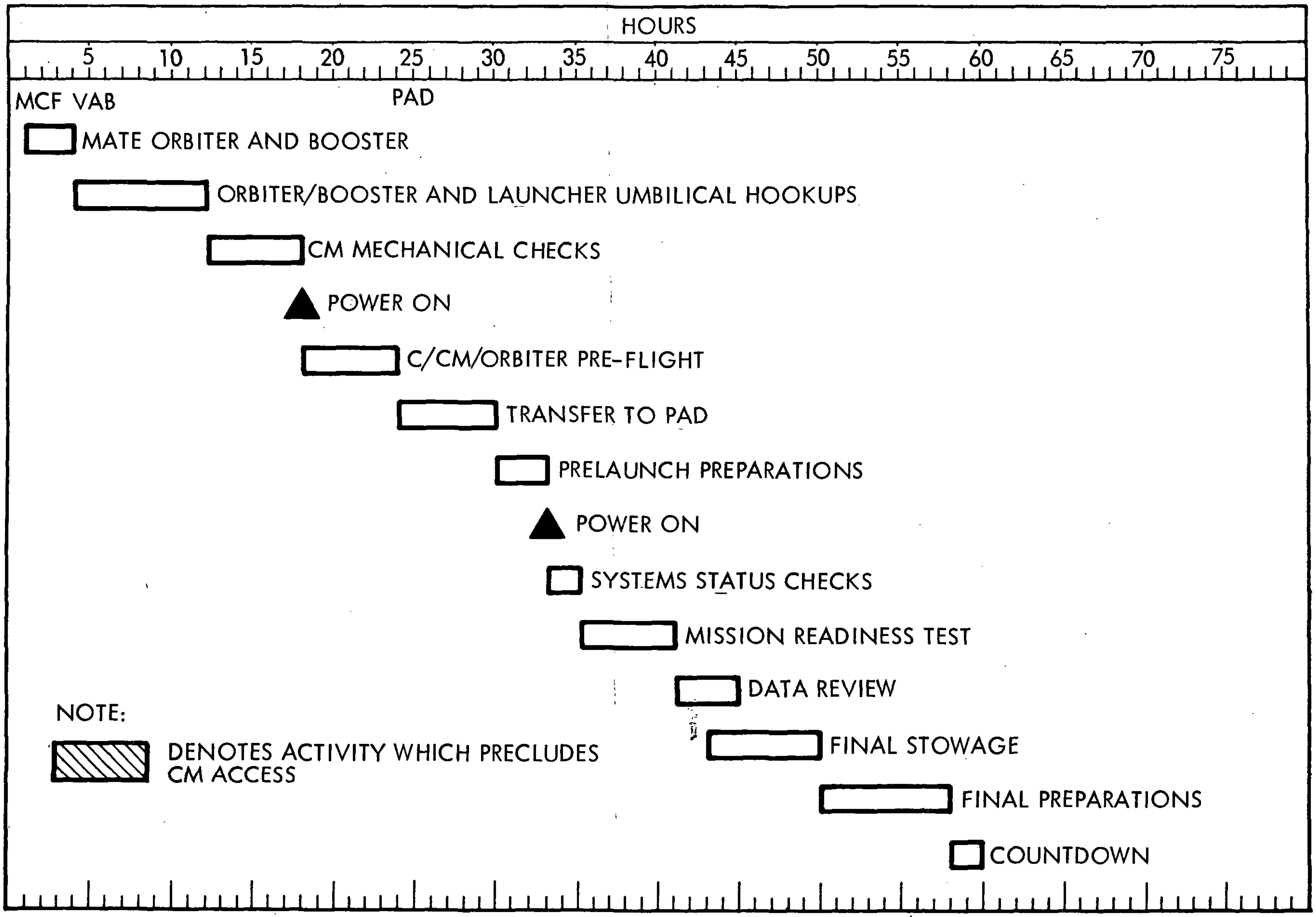


Figure 4.3-7. Cargo Module Vertical Processing—Prelaunch

Although there is no impact on the cargo module operations as a result of shuttle processing by the horizontal concept or vertical concept, it has been assumed that the vertical concept will be employed and timelines are established on that basis.

After transfer to the launch pad and shuttle to ground connections are made, the CM will be checked for preflight readiness. When power is available, status checks will be made in preparation for the mission-readiness test and data review, and final loading operations of time-critical cargo will be accomplished. This cargo will be loaded from the service arm that also is to be used for emergency egress.

Approximately 400 pounds of frozen foods are expected per flight on a normal resupply mission. No mechanical refrigeration will be required if the foods are subcooled to -100 F and packed in a precooled insulated container. A requirement has been established that the insulated container may rise in temperature from -100 F to +15 F within 72 hours. If the launch window of 60 seconds is not met, a hold period of 15 hours would not adversely affect the above requirement. A second hold of 15 hours probably would require the frozen food to be removed from the CM and rechilled or additional dry ice added to the insulated container.

Following the final cargo loading, the CM precountdown preparations will be accomplished. The countdown begins at T-2 hours, and the primary functions are as depicted in Figure 4.3-8.

High-pressure gas loading will be completed prior to passenger loading of the shuttle at T-45 minutes.

The present baseline booster, orbiter, and CM configurations will require three separate boarding access platforms. The launch pad facility or service tower will provide standby ready rooms and rapid lift capability to accommodate crew and passengers during the final stage of propellant loading and to move them to the boarding platforms. All personnel will board simultaneously as soon as propellant loading is complete.

Flight crews and passenger loading in the orbiter should be completed in no more than one-half hour. To reduce total launch operations time to a minimum, the flight crew will initiate early stages of final launch countdown as soon as they are in place and have secured their access hatches. Thus, early stages will be concurrent with completion of passenger boarding and will require a final safety clearance signifying passengers are secure and ready to launch before the flight commander starts the engines.

Final countdown and launch will be controlled automatically by the shuttle's on-board computer and will be completed not more than 15 minutes

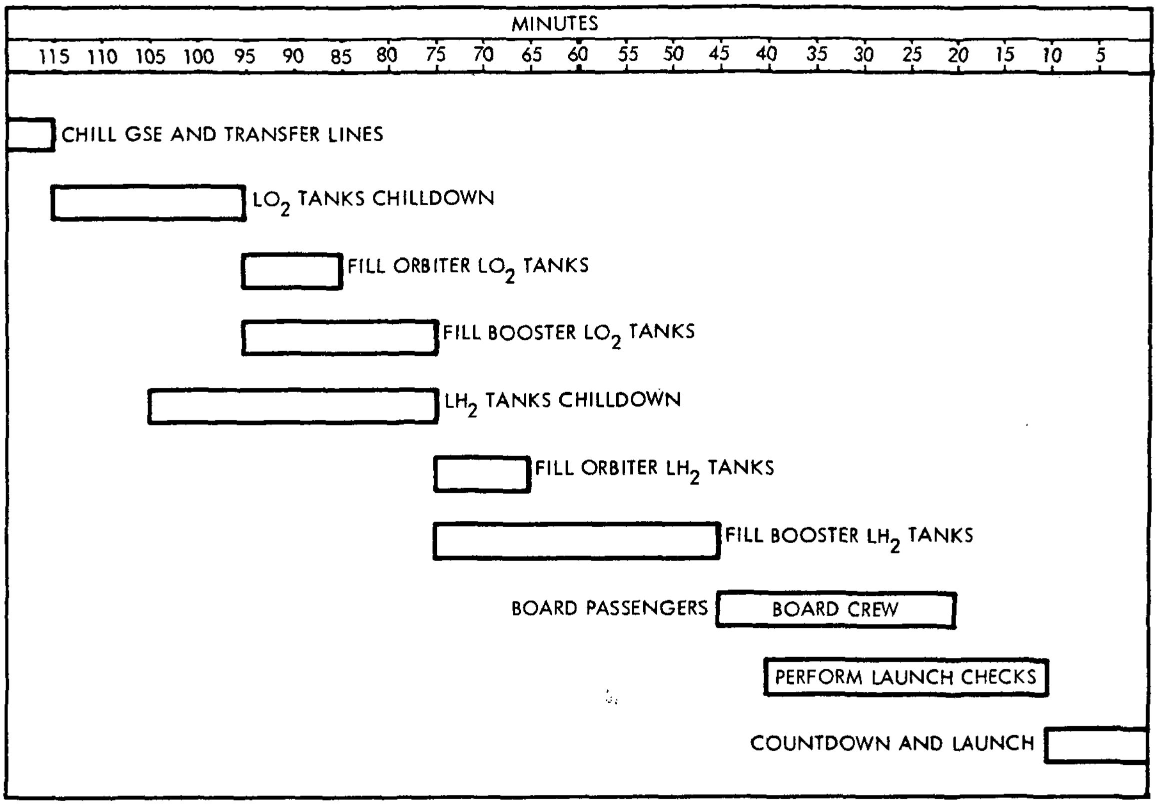


Figure 4.3-8. Launch Countdown Operations

from the time of completion and securing passenger loading. The flight commander (or automatic sequenced countdown) must obtain a passenger-secure signal from the orbiter before entering the final stage of countdown. Safety and abort analyses indicate a firm requirement for holddown to verify proper booster propulsion performance before releasing the vehicle for flight.

The present operations concept assumes that flight status is achieved after 1 foot of vertical travel. From that point on, the shuttle is in the flight mission phase under control of the mission commander. On-board computer control during final countdown and flight mission will reduce ground personnel requirements to a minimum necessary for monitoring and safety.

4.3.2 POST-LANDING OPERATIONS

Post-landing operations (recovery) include the functions of crew, passengers, cargo removal, and preparation for maintenance. Figure 4.3-9 represents the basic activities that comprise post-landing operations.

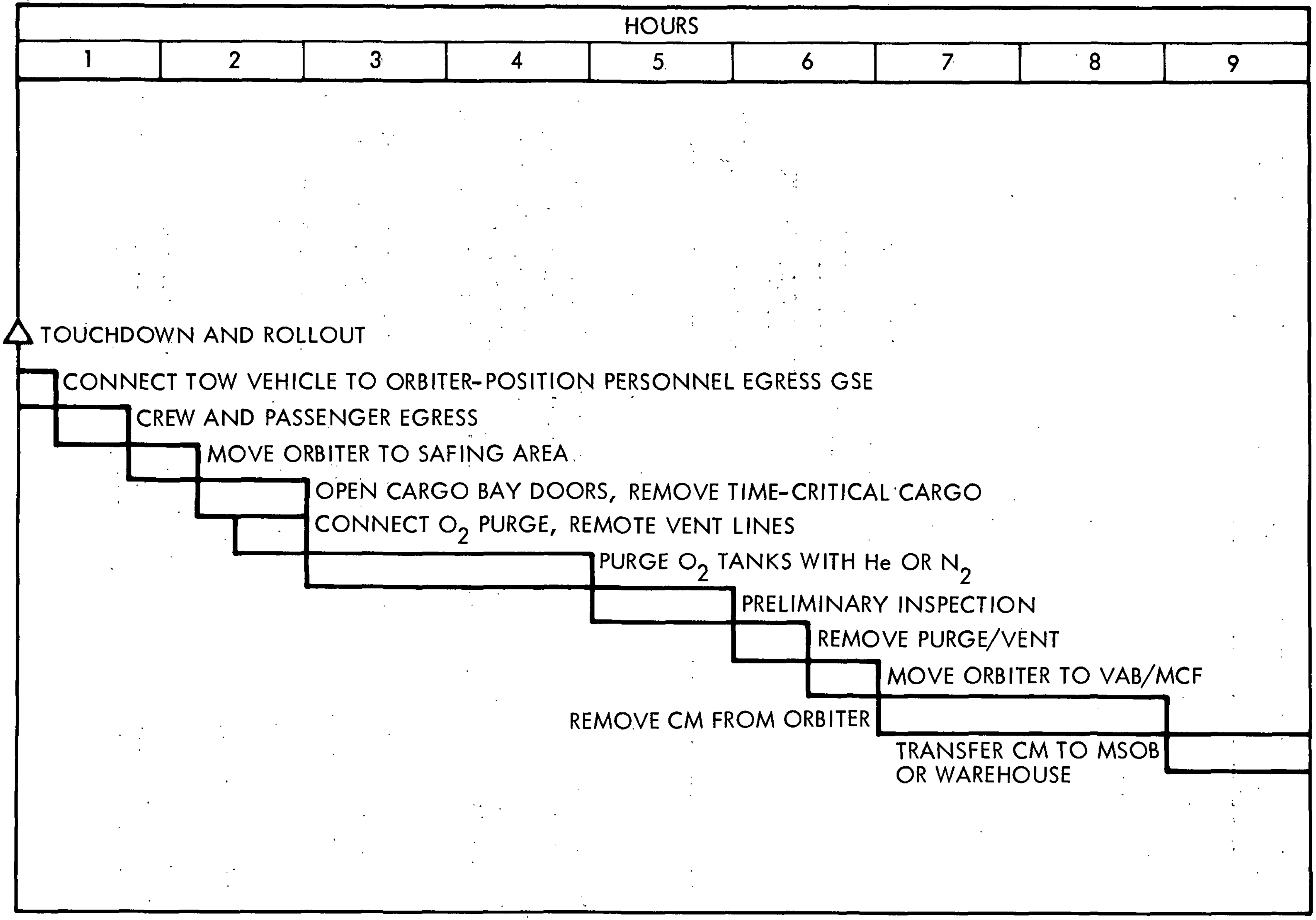


Figure 4.3-9. Post-Landing Operations

After landing and clearing the runway, the orbiter flight crew will initiate on-board safing procedures and shut down the systems. The orbiter then will be taxied or towed to the safing area for passenger and crew egress.

4.3.3 PASSENGER AND CREW UNLOADING

Crew and passengers normally will leave the orbiter (after it has been towed to the safing area) by means of an egress system provided as part of the facility. A means of leaving the orbiter, prior to towing to the safing area, also will be provided. The passengers will return in the orbiter compartment and will egress directly from the area with the crew. The cargo bay doors will be opened as soon as possible after the orbiter has been towed to the safing area.

4.3.4 SAFING THE CARGO MODULE

The orbiter will be safed and serviced in the safing area (Figure 4.3-10). This function will include vehicle coolant and conditioning, detanking, purging, and venting. Preliminary visual inspections will be initiated during this time.

The CM will land with residual vapors in the tanks. Thus, post-landing operations will include purging the oxygen tanks with gaseous helium or nitrogen. The nitrogen and helium tanks will not require purging.

After the orbiter has been defueled, purged, safed, and the necessary preliminary inspections completed, the cargo bay doors will be closed and the vehicle towed to the maintenance and checkout facility located at the modified VAB. After positioning in the maintenance bay, the work stands will be positioned, the cargo bay doors opened again, and the CM removed with the facility crane. The CM will then be transported to the assembly and delivery site by means of the transporter. All down-cargo will be removed and the CM prepared for maintenance operations as discussed in the next paragraph.

4.3.5 MAINTENANCE OPERATIONS

Maintenance operations on the CM comprise the functions and activities from the conclusion of post-landing safing and servicing to prelaunch operations.

Scheduled maintenance will include those activities required for modification of basic structure and passenger equipment such as seats, EVA equipment, emergency equipment, food, water, waste management, provisions tools, and other mission-related equipment. Trend data will be determined from an evaluation of the recorded flight data, which will be used

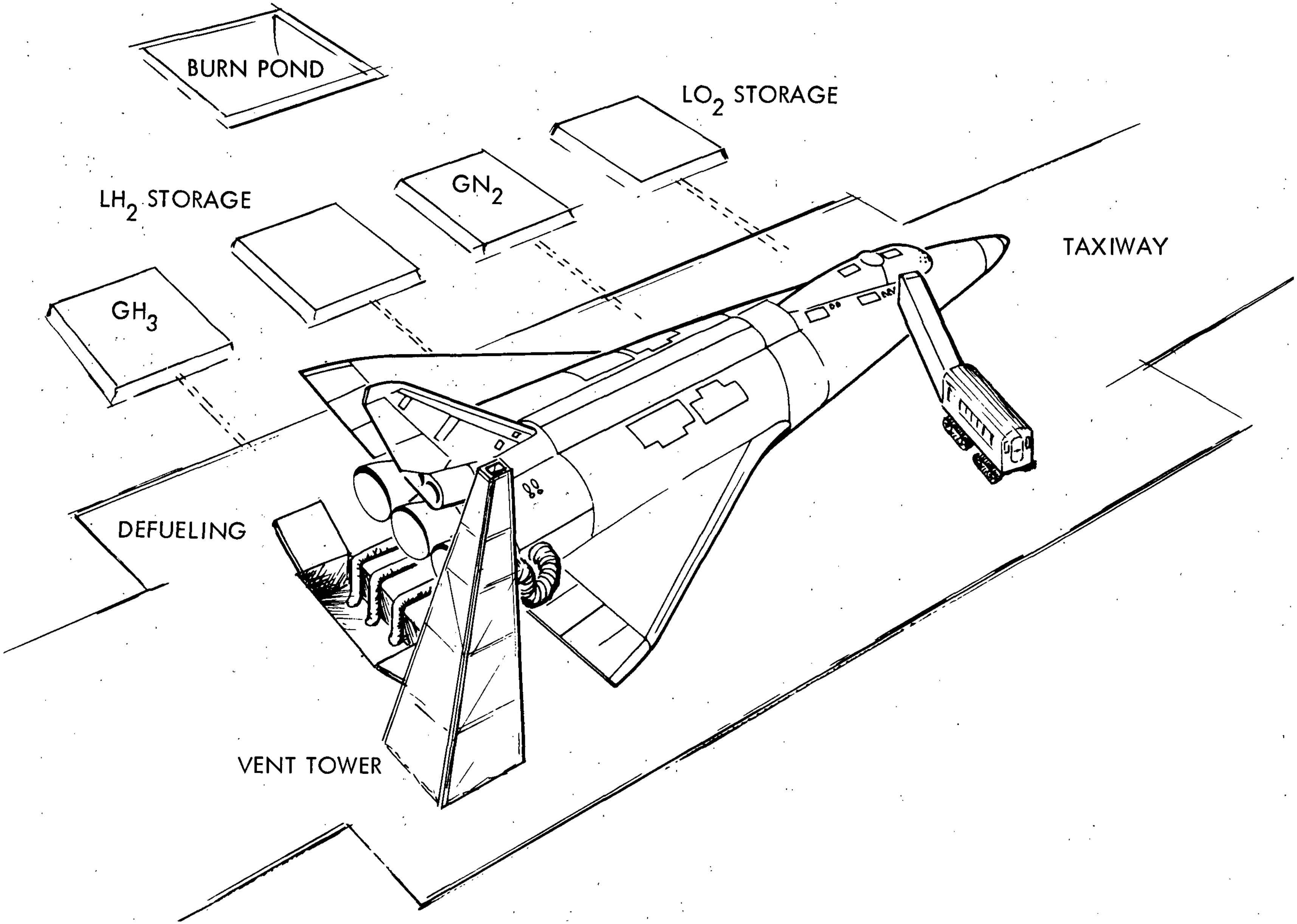


Figure 4.3-10. Orbiter Safing Area

to establish scheduled replacement of subsystem and/or components. Inspection performed during this activity may disclose additional requirements for unscheduled maintenance.

4.3.6 CORRECTIVE ACTION

Major modifications may require recycling the CM to the MSV to verify interface compatibility and/or to confirm revisions to operating procedures.

Unscheduled maintenance will be largely controlled by recorded flight data and crew reports. Analysis of these data will be used to identify unscheduled maintenance activities and, when integrated with trend data, will provide a basis for changes in scheduled maintenance activities.

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4.4 TRADE STUDIES

Originally, this study included an assessment of the cargo module for Saturn A, which required cryogenics. Although the previous sections of the report are updated to be compatible with the MSS, cryogenic considerations are not deleted from this section, because the data may be useful for other payloads with similar requirements. Also, the last concept does not permit passengers to occupy the cargo module during boost nor during entry and launching.

4.4.1 HAZARDOUS FLUID LOADING

A trade study for loading both high-pressure gases and cryogenic was conducted during this study. The primary considerations were:

1. Load fluids (high-pressure gases or cryogenics) prior to loading the module in the orbiter cargo bay

2. Load fluids at the launch pad. Secondary trades for the alternative of loading fluids at the launch pad were:

    a. Load through the orbiter interface

    b. Load directly through a space station module/ground interface.

Table 4.4-1 depicts a trade summary of the two alternative loading concepts. The approach selected is to load fluids at the launch pad, with the loading being based primarily on the safety considerations of both hardware and personnel.

4.4.2 WEIGHT AND BALANCE DETERMINATION

The weight and center-of-gravity constraints imposed by the space shuttle will dictate the determination of those parameters prior to launch. A trade was made to determine the most appropriate location and point in the prelaunch processing to perform the weight and center-of-gravity location and the manner in which it will be accomplished.

Table 4.4-1. Space Station Module Fluid Loading

Load Fluids Prior to Mating		Load Fluids at the Pad	
Rationale for selection: 1. Reduce interfaces to orbiter. 2. Reduce access requirements after loading 3. Reduce GSE/LUT-mounted fluid distribution system complexity		Rationale for selection: 1. Reduce heat transfer time to fluid. 2. Reduce safety hazard potential exposure	
Pro	Con	Pro	Con
1. Loading done under optimum control with no time-critical path. 2. No interface with orbiter or GSE at pad. 3. No command and control system required at pad.	1. No safing or off-load capability at the pad. 2. Safety hazard potential introduced for longer period. 3. Requires pressure vessel remote monitor capability for longer period. 4. Requires facility modifications for hazard-proofing VAB or relaxation of safety requirements. 5. Requires additional move and uses additional facilities.	Reduce safety hazard potential exposure time	1. Requires additional GSE. 2. Requires command and control functions 3. Requires orbiter or ground interface.

It is required that the modules be weighed because of the following:

1. Variability of cargo precludes the accurate computations of weight and c.g.

2. The bulk of the weight is cargo, and the cargo is variable.

3. The module configuration is flexible to accommodate various missions and changes in shuttle loading.

Module weight and c.g. determination must be accomplished prior to loading into the orbiter and after cargo has been loaded. This clearly indicates that it must be done at the launch site.

Alternative locations for performing the weight and balance operation are at the (1) VAB, (2) MSOB, or (3) warehouse.

The MSOB is the selected alternative based on the rationale discussed in the following paragraphs.

The VAB and/or MCF were eliminated because of the probability of interfering with shuttle vehicle operations at that facility.

Consideration of the warehouse led to the elimination of it as an alternative because of other activities there and because setting up a weight and balance operation there would not be convenient for other than cargo modules.

The selected alternate is the MSOB where all other module work is accomplished.

After the cargo is loaded in the cargo module, the vehicle will be returned to the MSOB for weight and balance. The time-critical cargo, resupply gases, and passengers, if applicable, will not be included at the time the weight and c.g. location are determined. These additional weights will be computed into the data to derive the flight parameters.

4.4.3 MSS PROGRAM ELEMENT ACCESS PROVISIONS

Figure 4.4-1 illustrates the concepts for access to the CM that have been studied with the orbiter nearest the LUT (Figure 4.4-2). Table 4.4-2 shows that method A provides normal ingress and egress routes for the passengers. Method B provides emergency egress routing. Method C is a combination solution providing both normal ingress and egress and emergency egress. Method C also provides the access required for loading time-critical cargo. The function of method C operations are discussed in the following paragraphs.

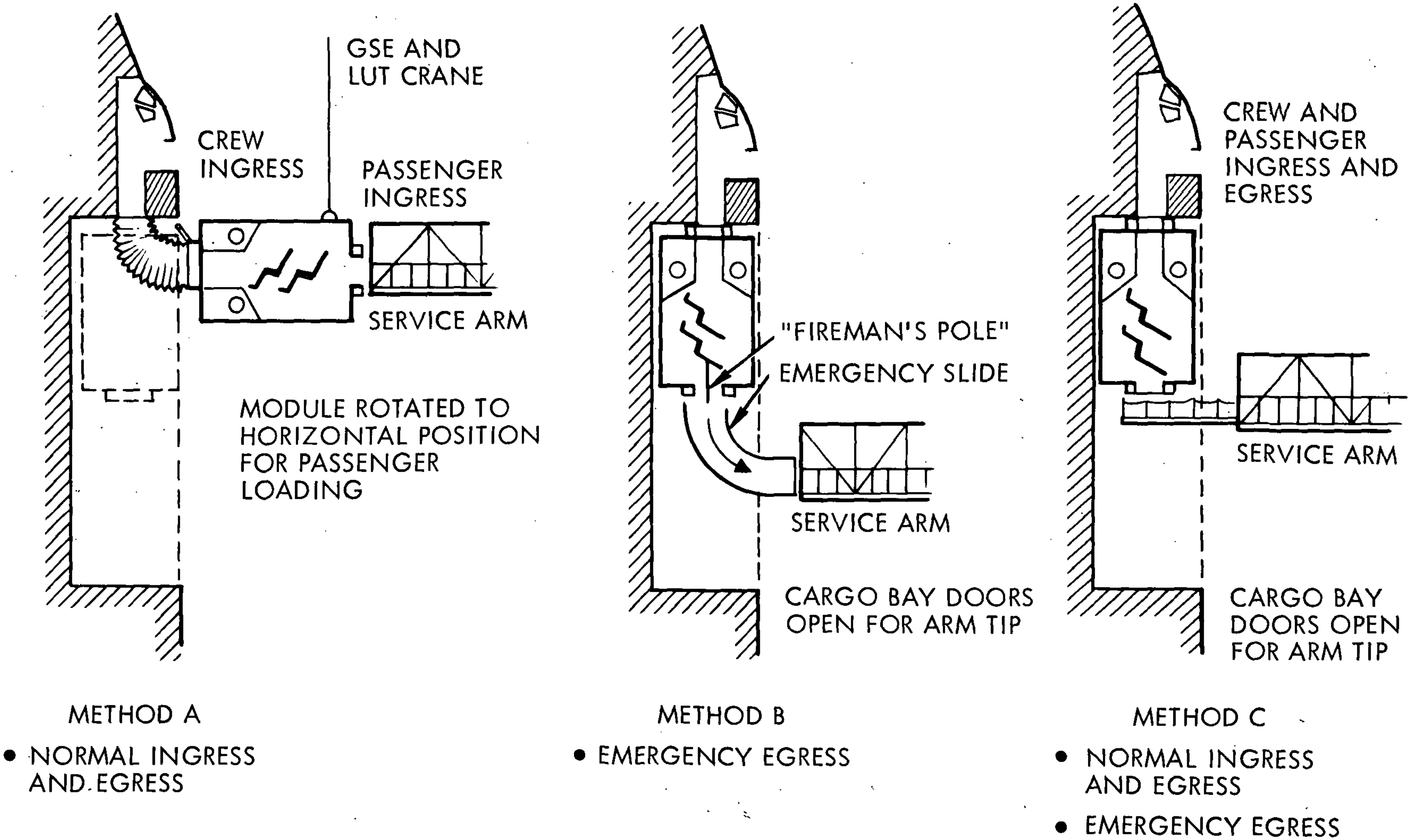

Figure 4.4-1. Launch Pad Access to C/M—Position A

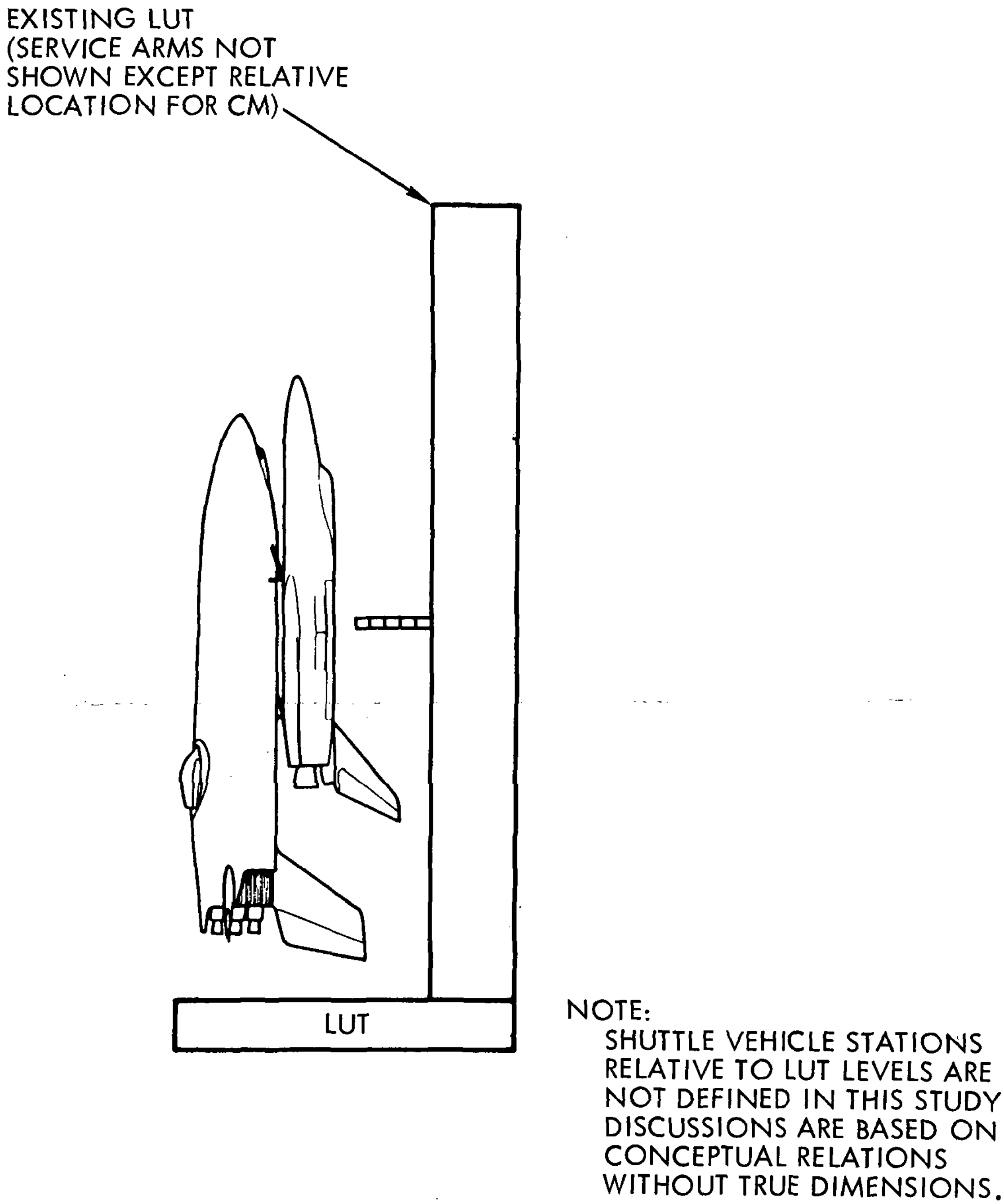

Figure 4.4-2. Shuttle Launch— Position A

Table 4.4-2. Comparison of Ingress/Egress Trades

Method A	Method B	Method C
ADVANTAGES		
1. Easy to get in and out - seats easy to get into 2. Easy to load time-critical cargo	1. Rapid egress	1. One swing arm 2. Accommodates normal ingress and egress plus emergency egress route 3. Easy to load time-critical cargo 4. Rapid egress
DISADVANTAGES		
1. Requires time to swing out and position arm 2. Not compatible with existing LUT 3. Requires additional swing arm for hooking up swing out GSE	1. Requires fireman's pole, dead weight, and stowage 2. Requires tunnel dead weight and removal for docking and swing out 3. Requires additional swing arm provision to install tunnel (same as used for egress)	1. Difficult to get in and out of out of seats 2. Seats may require new pivot capability

The service arm length enables the cargo bay doors to be opened and closed with the arm in place and the arm tip retracted. When the cargo bay doors are opened, the arm tip is extended to a position under the aft docking port of the CM.

Umbilical connections could be made directly to the aft docking port and disconnected with movement of the arm just prior to lift-off allowing the safety egress route to remain in place until launch commit. Arm tip control would have both manual and remote-control capability.

Normal ingress and egress may be through the orbiter hatch and into the CM or via the access arm or both, depending upon whether the cargo bay doors are open or closed.

In space, when the CM is docked to the space station, ingress and egress is through the aft docking port from the shuttle.

Figure 4.4-3 illustrates the concept with the booster nearest the LUT. This concept requires an access arm that is approximately 130 feet long and makes the use of a second arm a requirement. Ingress and egress of the CM must be through the orbiter crew compartment if only one arm were used.

Several methods of emergency egress have been considered. Among the concepts considered were:

1. Use of mobile service structure. Techniques were studied of removal of the entire CM and use of access platforms and egress routes similar to method C described with the orbiter near the LUT. Although there are feasible solutions to the emergency egress problem utilizing the mobile service structure, they have not been pursued because of the unacceptable risk of loss or damage to the structure at launch. The timelines of the crew ingress during a countdown are such that the structure could not be moved a safe distance from the booster at launch.

2. Use of overhead crane devices were studied for emergency egress by lowering the personnel or by lowering the entire CM to the ground level. This concept was ruled out because it offered no alternate route in the event that a condition existed that precluded occupancy of the area in the immediate vicinity of the base of the launcher.

3. Use of the ingress arm at the orbiter crew compartment hatch is another practical route for emergency egress. This route provides access to the tower where either elevators, slide wire, or

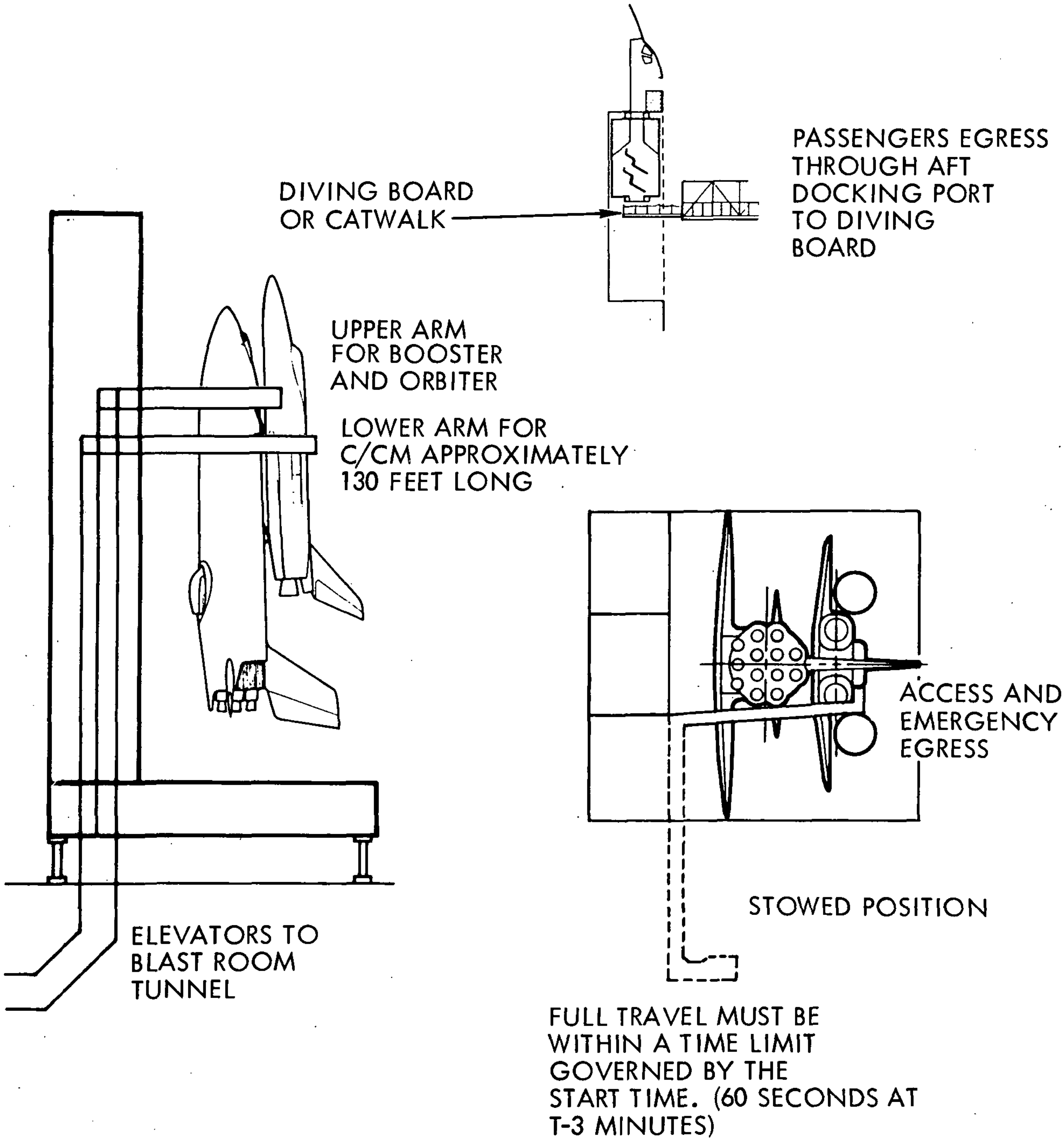

Figure 4.4-3. Shuttle Launch— Position B

other means of a route to safety are available. This method is not considered to be adequate because of the necessity to proceed upward from the CM to the hatch and because of the number of personnel involved.

4. Use of two ingress/egress arms with high speed or semifree-fall elevators provides a more satisfactory method for emergency egress from the booster and the orbiter and from the CM. By providing an access arm that can be positioned in front of the cargo bay doors, an egress route is provided that is the nearly equivalent to method C described for the shuttle positioned on the LUT with the orbiter next to the tower.

   The dynamics of an arm this size are quite complex; however, because it does not have to be retracted at liftoff, it can be positioned slowly enough to handle its inertia.

Prelaunch abort criteria for the shuttle led to an alternative approach of including the passengers in the orbiter for launch and landing. Figure 4.4-4 depicts the service arm arrangement for the flight personnel compartment envisioned in the current shuttle studies as shown in Figure 1.4-3.

With this concept, emergency egress is accomplished by way of the overhead hatches that lead to service arms and the launcher tower. This configuration would dictate the use of one service arm and hatch for loading time-critical cargo and passengers for the space station.

4.4.4 UMBILICAL LOCATION

The concept of loading fluids prior to placing the module in the orbiter would eliminate the launch pad connections and controls for that operation.

The selected approach for fluid loading required umbilical connections between the ground equipment and the space station program element for nitrogen, oxygen, hydrogen and helium fill and vent lines, and the electrical power, command, and control functions for loading or venting these tanks.

The location of the umbilical is subject to operational considerations, and several approaches have been considered. Figure 4.4-5 shows three alternative locations for the ground umbilical for the space station modules.

One location considered was based on a shuttle study concept of ingress and egress through a side-wall hatch on the modules. This location is unacceptable primarily because of the problems associated with an external umbilical on the modules and a personnel access hatch at that location.

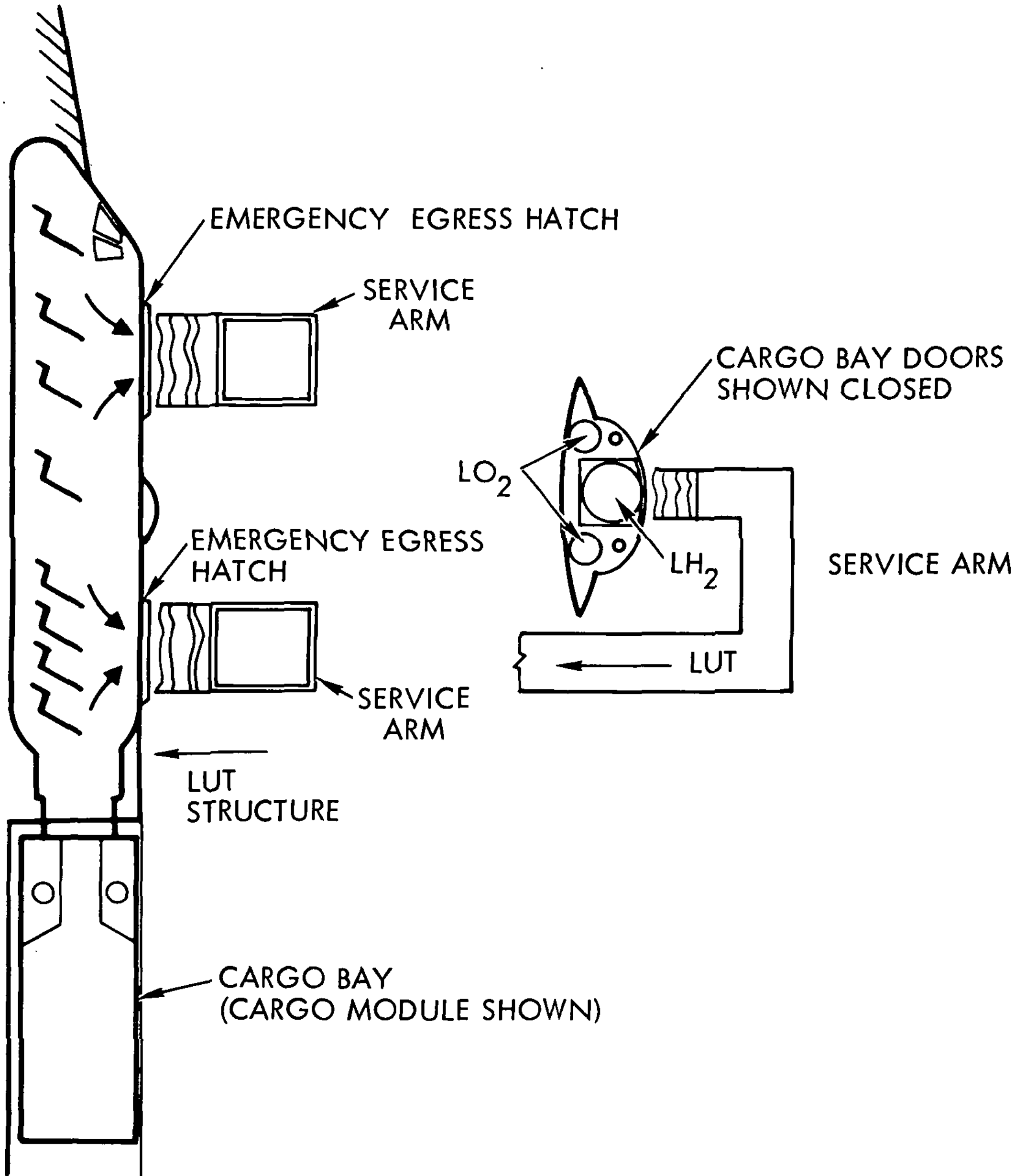

Figure 4.4-4. Service Arm Locations for Orbiter Crew Compartment

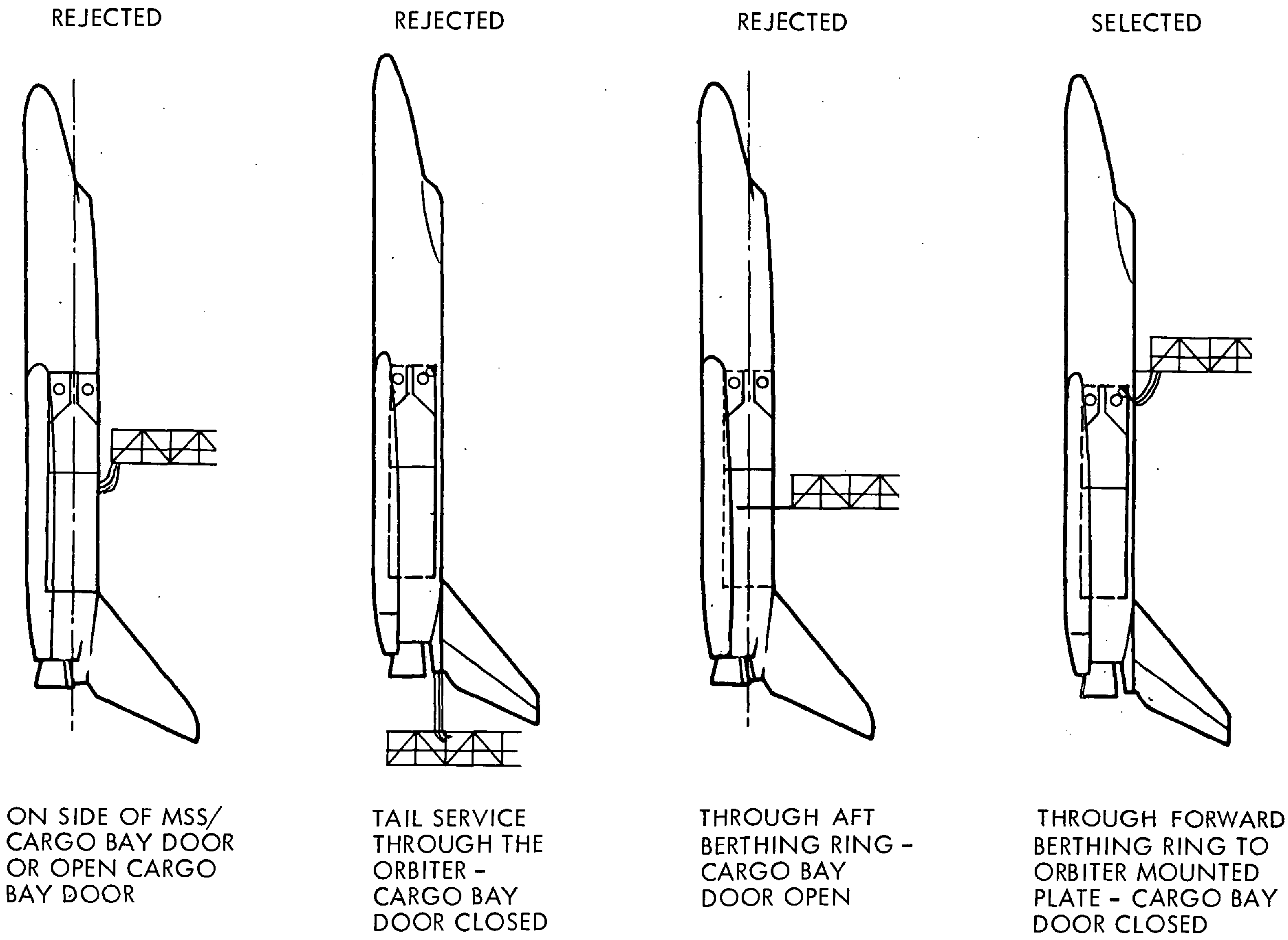

Figure 4.4-5. MSS Umbilical Location

Based on a concept of the shuttle using a tail service mast, the use of servicing lines was considered for MSS elements from this interface.

Servicing the MSS elements through the orbiter tail service connection was concluded to be undesirable because of the line runs from the GSE to the modules and the weight penalty of added on-board hardware.

This concept is a candidate for the umbilical location. There would be no operational problems of using tail service connections if engineering design indicates that concept to be the best location.

Another location considered would locate the umbilical on a service arm and thus connect it to the module aft docking interface. This location would utilize an existing interface and would be compatible with the service arm location considered for emergency egress and time-critical cargo loading.

Locating the umbilical on the orbiter fuselage, forward of the cargo bay, also was considered. This location was considered because of the concept of the passengers occupying the orbiter crew compartment during launch and reentry, which would require a service arm at the hatch adjacent to the passenger section of the orbiter. The service lines would utilize this service arm for access to the umbilical interface.

This location would require adequate provisions within the orbiter to interconnect the module and the umbilcal panel.

As an example of the complexity of the umbilical, the station module to core module interface can be used as an upper limit. The ground interface would be less complex than this interface. The station-to-core-module interface carries 15 fluid lines and ducts of which five fluid lines require barriers vented to space. The electrical interface consists of 14 power connectors, 16 coaxial cable connectors, and six twisted, shielded pairs, for a total of 36 electrical connectors on each side of the interface.

For the purpose of consistency, the selected location of the umbilical is on the orbiter fuselage, forward of the cargo bay, interconnected to the module forward docking ring interface.

4.4.5 COMMAND AND CONTROL

Throughout this study one of the primary goals has been to minimize the access, servicing, and checkout of the MSS modules after they are loaded in the cargo bay of the orbiter. Loading of gases in the power module and resupply gases in the cargo modules will require sufficient command and control functions for this servicing at the launch pad.

Techniques were considered to provide the MSS elements ground command and control necessary for prelaunch servicing as depicted in Figure 4.4-6.

The requirement for essential command and control could be satisfied by allocating sufficient functions of the shuttle command and control system. Because the MSS is not a driver in the selection of the shuttle system, several alternatives are used for this study to analyze the effect on launch operations of the modules.

Figure 4.4-7 schematically depicts a typical command and control system utilizing existing equipment from which requirements can be determined. The requirements include electrical power, environmental and cooling air ducts, gas storage bottle valve controls, ground equipment for fluid transfer and venting, and instrumentation for monitoring the operation.

4.4.6 CARGO LOADING

On the basis that vertical cargo loading makes for easier loading and unloading, plus the flexibility afforded for cargo retrieval while in orbit, the recommendation was to specify the vertical cargo loading concept (transverse bulkheads) for the Phase B study of the CM (Reference SD 70-540).

The basic cargo loading and handling concept is to prepackage cargo into standard-size containers that have an average weight of 50 pounds. Four of these containers would be palletized—that is, held together in such a way that they can be handled (on the ground), transported, and loaded as one unit.

Considering the advantages of establishing a standard size cargo container as well as the maximum size and weight recommended for individual packages, this study shows that a container in the range of 19 to 25 inches square would be satisfactory for the purpose of evaluating the relative merits of a longitudinal floor versus a transverse bulkhead configuration. Determining the actual size, shape, and volume of a standard cargo container was not the objective of this study.

IFRU's that do not fit into a standard cargo container would be individually packaged and secured for flight. This approach is deemed acceptable on the basis that there will be very few items in this category. Most resupply items are not restricted by physical size.

General access and available space inside the CM shows that material-handling equipment cannot be employed very easily in the horizontal loading position. This is a significant factor in recommending the vertical cargo-loading concept.

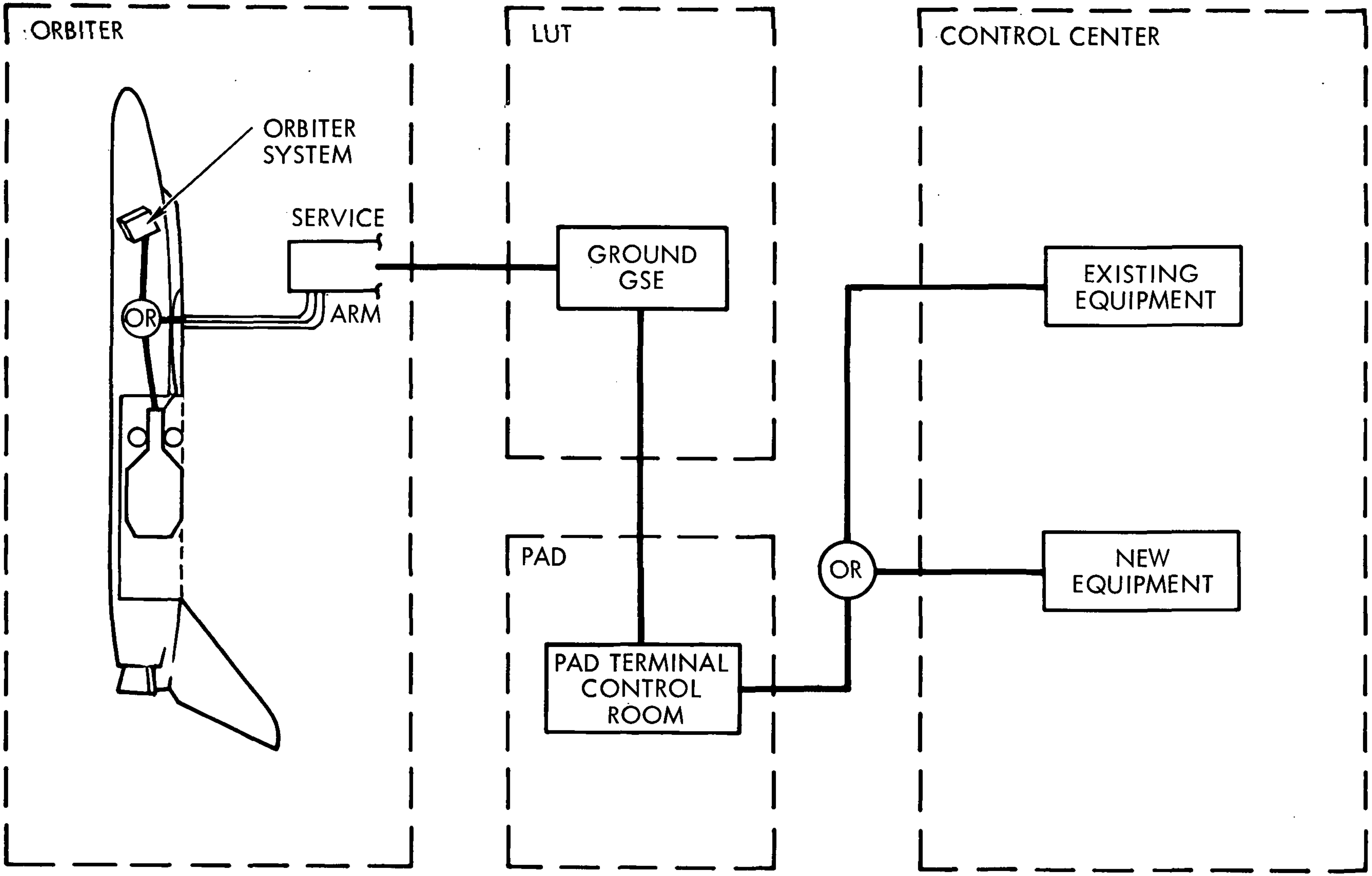

Figure 4.4-6. Command and Control Alternatives

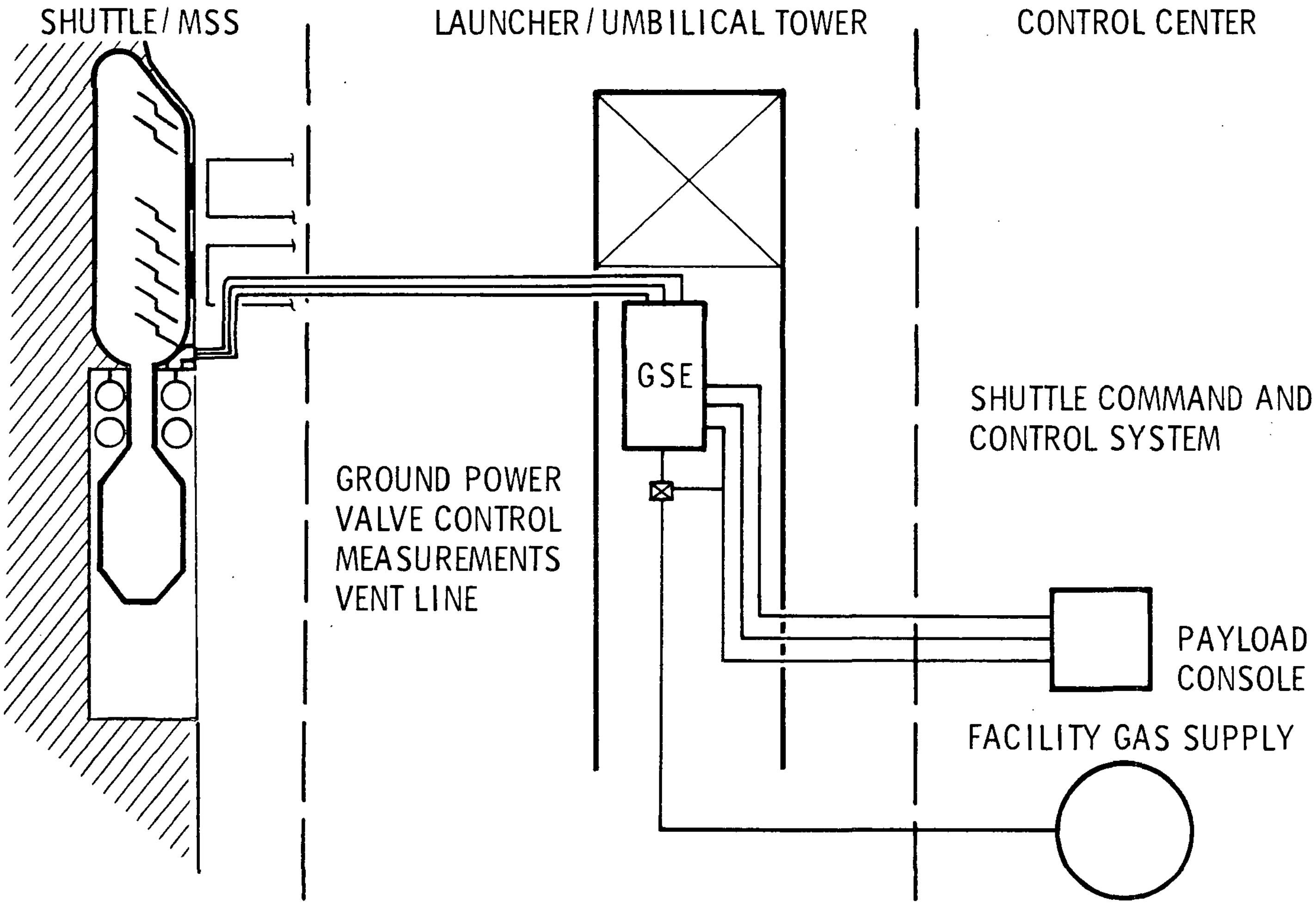

Figure 4.4-7. Ground Command and Control Functions—Typical

The estimated time to load cargo revealed that the vertical cargo-loading concept would save approximately 3.0 hours or 7.8 man-hours. The estimated time to unload cargo revealed that the vertical cargo loading concept (transverse bulkheads) would save about 1.0 hours or 2.0 man-hours. Of significant importance, however, is the relative ease of access to individual pallets or containers with the transverse bulkhead configuration. The horizontal method of loading cargo would require much more care in loading pallets, so that those with perishable foods or high priority items could be reached without first removing those with less important cargo.

Because the horizontal loading operations do require the operation of some kind of lift and lowering device, plus side maneuvers and hand guidance, the loading time is estimated to take almost three times as long as a vertical loading operation.

Horizontal loading also suggests that all pallets should be kept in a horizontal position for easiest handling and maximum safety. More pallets can be loaded in this manner. Length of pallet is limited to 70 inches between (partial) bulkheads; this dictates that the cargo container height should be no more than 17 inches.

Figure 4.4-8 depicts the basic approach to loading palletized cargo in a vertical manner. The concept is to lift two pallets at a time by means of an elevator to the required deck and roll each pallet to its tie-down position. Each pallet will be rigidly attached to the deck to sustain 1-g and launch loads. Each pallet also will be tied to the deck above for stability and negative loads. No major material-handling equipment is required inside the CM (except for the elevator). One man working inside the CM can adequately load all palletized cargo. All pallets are kept in a vertical position.

External access platforms will allow easy access for inspection and changing of storage and transfer components. A 360-degree access would be available to this important work area.

Based on the results of the NR Space Division analysis of cargo loading, trades were made to identify facilities and equipment for use at the launch facility.

Existing KSC buildings and a new building were considered as candidates for the logistics operation as shown in Table 4.4-3.

The table shows that the Apollo warehouse and the Pyrotechnic Installation Building (PIB) were nearly equal in the analysis. The warehouse

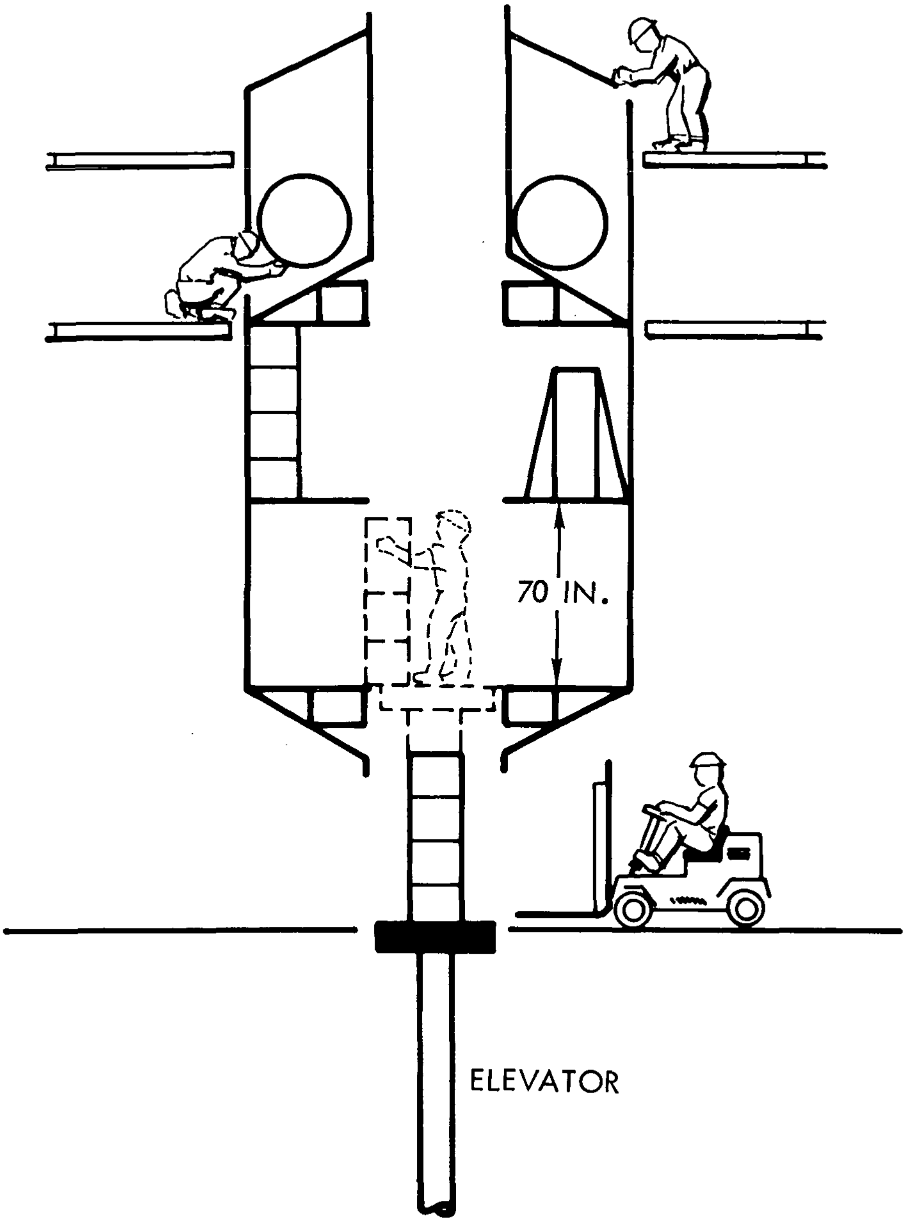

Figure 4.4-8. Cargo Loading, Transverse Bulkheads

Table 4.4-3. Cargo Loading Facility Trade

Requirements	Weight Factor / Cost	MSOB 8	Warehouse 8	VAB 8	New Building 0	PIB 8
Cargo storage space	10	0	10	10	10	10
Work stand	5	5	5	5	5	5
Overhead crane	2	2	2	2	2	2
Cargo loading device	5	- - M O	B I L E	- - -	- - - - - -	- - -
Controlled environment	5	5	0	0	5	1
Proximity to checkout area	3	5	3	0	3	1
Total	30	23	28	25	25	27

PIB - Pyrotechnic Installation Building
MSOB - Manned Spacecraft Operations Building
VAB - Vertical Assembly Building

was considered slightly more favorable, and the PIB is possibly committed for another space vehicle program; therefore, the warehouse was selected for one of the facilities used by the MSS program.

The MSOB is planned for use by the MSS flight modules and MSV operations and, hence, will be used for cargo module checkout, configuration activities, and weight and balance as discussed previously.

A cargo lift device is required to accommodate the vertical load concept as depicted by the elevators in Figure 4.4-8. A lift of this type would require significant modification to the building selected; therefore, other means were sought. This requirement and the external access provision requirement can be fulfilled by existing equipment or existing design of equipment. The selected access stand is the H14-124 Apollo/CSM work stand. The Saturn S-II stage LH_2 tank servicing mechanism (A7-35) is a suitable candidate for the lift mechanism, with some modification to the physical dimensions of the platforms. In addition to the lift capability, this mechanism has an advantage over an elevator in that the platform can be rotated to facilitate cargo placement in the module. This concept is shown in Figure 4.2-2.

5.0 ORBITAL OPERATIONS SUPPORT

The mission operations support concept developed in Phase B studies for the modular space station is illustrated in Figure 5.0-1. The responsibilities associated with the major divisions of mission management, mission support, and crew training are as follows:

1. Mission management. Provides executive direction of the space station mission and exercises operational direction and control of all elements of the mission operations system. It also provides management, planning, technical support, and, as required, operational control to the orbiting space station elements.

2. Mission support. Provides the facilities, services, and equipment for tracking and communications to and from the space station, which are required for mission management.

3. Crew training. Provides the general preparation, indoctrination, familiarization, and procedural practice required to qualify crew members for tours of duty on the space station.

The purpose of this section is to analyze the experiment and logistics functions shown under mission management to determine the impact of providing this support at KSC. Figure 5.0-2 depicts the relationship among the principal activities identified under mission management. In addition to the already mentioned flight, experiment, and logistics operations, a fourth group of activities is identified and is referred to as support engineering. It is shown as a function, but it comprises activities that bear a close relationship to the principal line functions of experiment, logistics, and flight operations.

Subsequent discussions in this report focus attention on the requirements imposed on KSC by these operations. For convenience, these requirements are discussed as either experiment site operations or shuttle/MSV site operations.

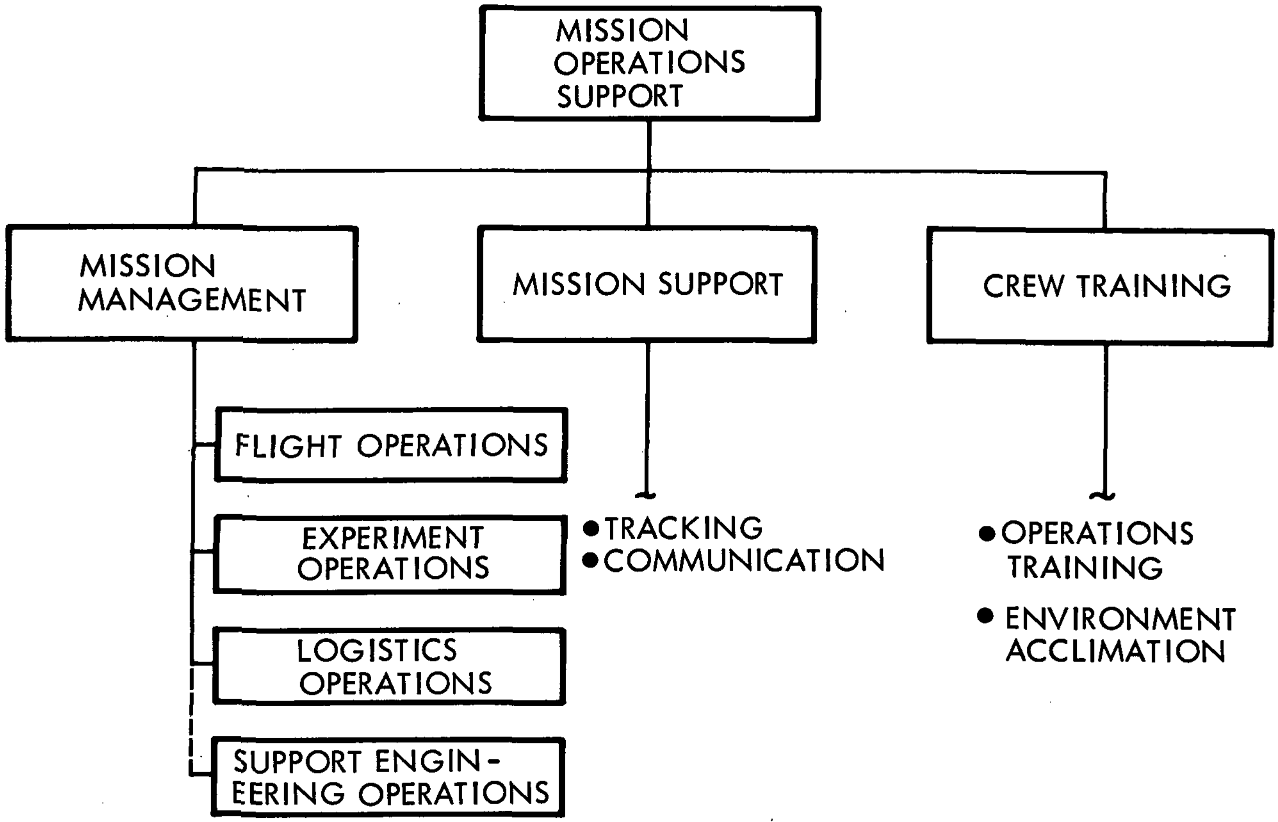

Figure 5.0-1. Mission Operations Support

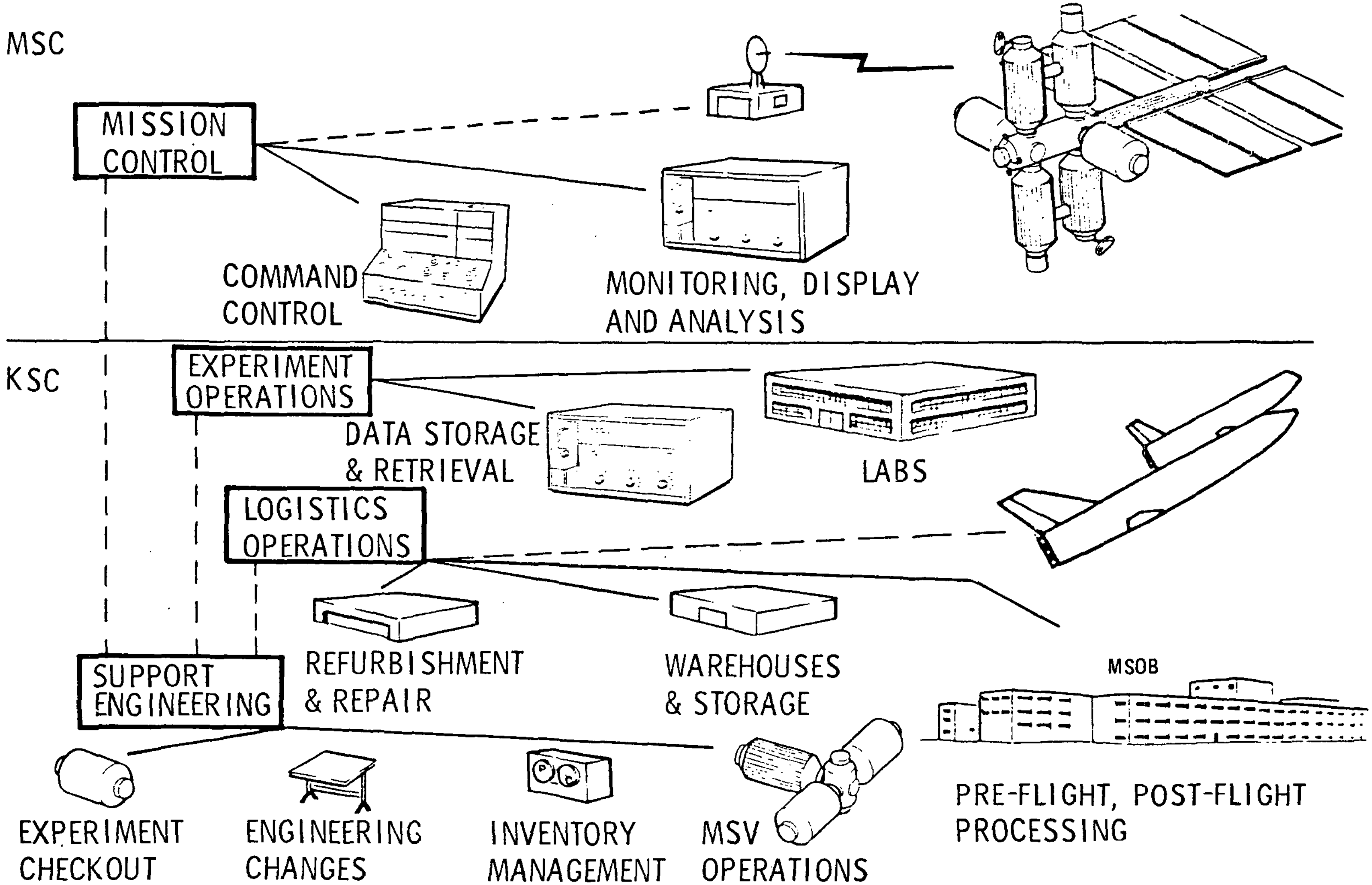

Figure 5.0-2. Mission Management Overview

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5.1 EXPERIMENT PROCESSING SITE

5.1.1 SCOPE AND GENERAL REQUIREMENTS

Figure 5.1-1 illustrates a reference experiment program defined for the MSS Phase B studies. While the program depicted is only one of several alternative programs, it represents a wide spectrum of disciplines and requirements that will be involved in any of the possible alternatives.

Some considerations that will influence the ground support concept are the following:

1. Large amounts of data will be generated and transmitted to the ground via the RF link or will be transported as down-cargo by the shuttle. A summary of these data outputs is given in Table 5.1-1.

2. A central data-handling facility for the storage of raw and processed data shall be provided to facilitate the coordination and transfer of data among the various data sources and data-users. This facility also shall include shops and equipment to prepare data-user packages from RF-transmitted or shuttle-delivered data.

3. Experiments that have a physical interface with the MSS will be integrated, and these interfaces will be verified with the MSV prior to launch.

4. Real-time monitoring and communication capability shall be provided on the ground to enable ground-based principal investigators or consultants to participate in observation, control, and evaluation of experiments being performed in the MSS.

5.1.2 SUPPORT CONCEPT

These considerations and requirements can be accommodated by the process and flows shown in Figure 5.1-2. The principal idea behind the concept is the establishment of a central experiment support facility which would perform all the functions previously defined.

Table 5.1-1. Experiment Data and Logistics Requirements

Experiment	Data			Logistics	
	Digital Data (bpd)	Hard Data (lb/day)	Imagery	Spares	Consumables
A-1. X-ray stellar astronomy	7×10^{8}	1	Control TV	52 lb/mo	8 lb/mo
A-2. Advanced stellar astronomy	6×10^{8}	1	Control TV	5 lb/mo	50 lb/mo
A-3. Advanced solar astronomy	6×10^{8}	5	Control TV	60 lb/mo	65 lb/mo
A-4. Intermediate UV telescopes	1.6×10^{9}	1	Control TV		12 lb/mo
A-5. High-energy stellar astronomy	5.2×10^{8}		Control TV	60 lb/mo	30 lb/mo
A-6. Infrared astronomy	6×10^{8}		Control TV		100 lb/mo LHe, 85 lb/mo
P-1. Space physics research	1.5×10^{10}				180 lb (tape, film)/mo
P-2. Plasma physics and EVV particles	8.6×10^{9}				18 lb (tape, fuel)/mo
P-3. Cosmic-ray physics	2.4×10^{10}				300 lb/mo (emulsion, film)
P-4. Physics and chemistry	2×10^{10}				100 lb/mo (film, tapes)
ES-1. Earth observations	4.7×10^{9}	5		240 lb/mo	25 lb/mo
C/N-1. Communications navigation	4.32×10^{9}	43			42 lb/mo
MS. Materials science and manufacturing	8.64×10^{8}	13.2	2.02×10^{10} 8-TV	88 lb/mo	515 lb/mo
T-1. Contamination and technology	2.72×10^{9}		10 MHz/2 hr		33 lb/mo
T-3. Extravehicular activity	1.94×10^{8}	21,600 feet			220 lb/mo
T-4. Advanced spacecraft system tests	1.0×10^{8}				72 lb/mo
LS-1. Medical research laboratories	9.18×10^{8}				25 lb/mo
LS. Biosciences laboratories (LS-2, LS-3, LS-4, and LS-5)	2.0×10^{7}	10 reels/mo 300 frames/mo			75 lb/mo
LS-7. Man system integration laboratory	7.2×10^{5}				45 lb/mo

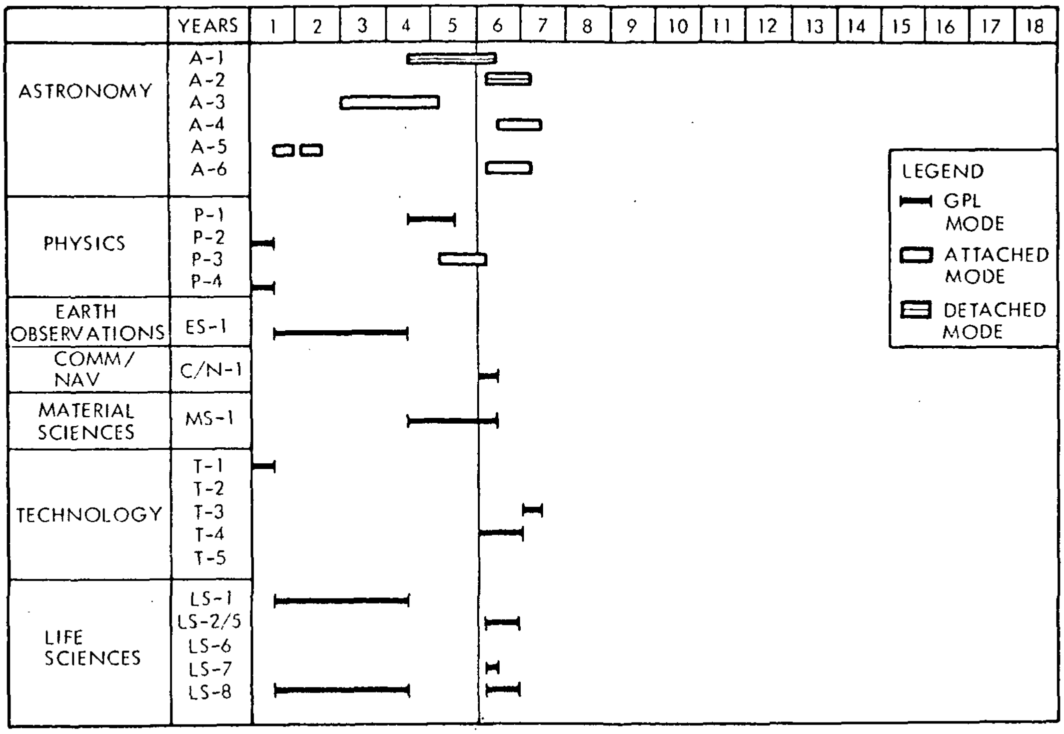

Figure 5.1-1. Experiment Blue Book Reference Program—Level II

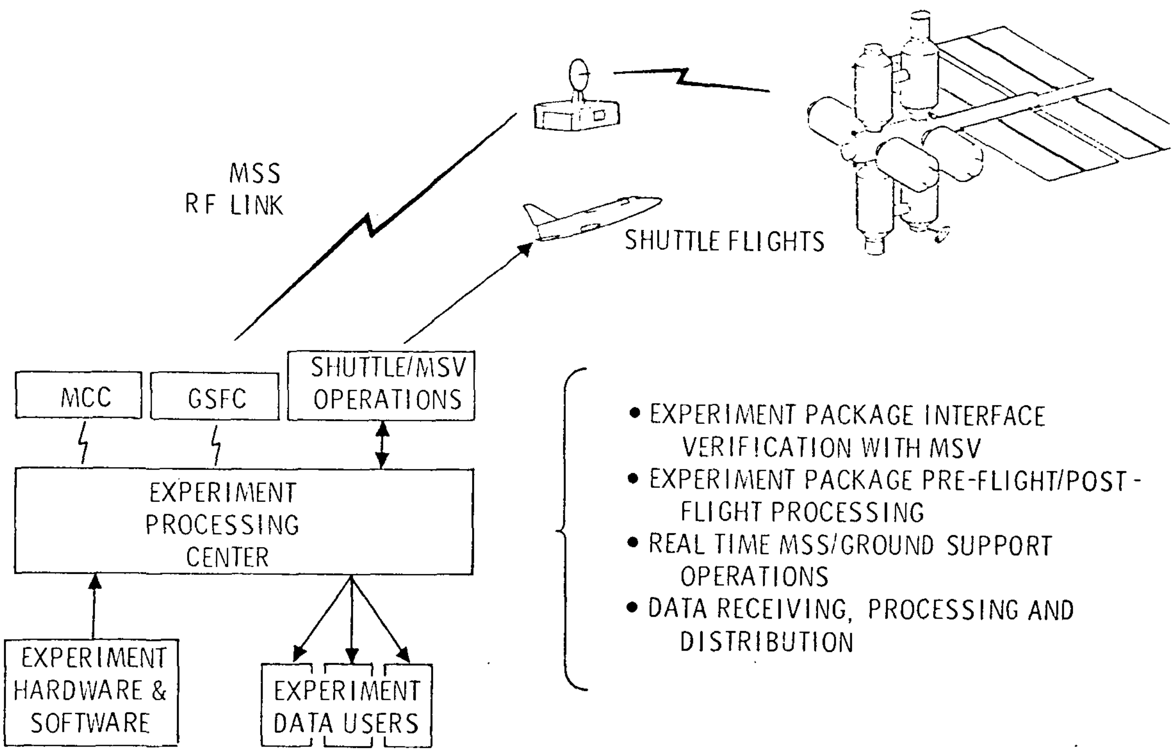

Figure 5.1-2. Experiment Processing Center Concept

The rationale for establishing this experiment support center is based on the recognition that some functions are, by necessity, required at the shuttle/MSV site. It is therefore possible, by assigning the other responsibilities to this site, to prevent the duplication of certain laboratories and shops and to shorten the communication and transportation links between experiment support facilities.

For example, the prelaunch processing of experiment instruments and software will require the MSV for system verification and compatibility checkout. Because of this requirement and the specialized nature of these experiments, instruments, laboratories, shops, and personnel will have to be made available at the shuttle launch site. In addition, processing of biological and physical specimens during the prelaunch and post-orbital activities will necessitate the location of analytical laboratories and trained personnel at the shuttle launch site. It would be advantageous, therefore, to locate also the preliminary assessment and experiment evaluation facilities for the experiment data center at the same site, because they will require similar laboratories and shops.

Following the same rationale, the facilities for real-time communications control for experiments should be located at the shuttle launch site, because they will require access to facilities such as the MSV for configuration verification and familiarization. They also will require access to analytical laboratories for near real-time experiment assessment and corroboration.

5.1.3 FACILITIES AND GSE REQUIREMENTS

The experiment support center will provide the facilities for experiment performance evaluation, experiment communications, real-time down-link data processing and display, experiment data storage and user data package preparation, and experiment package integration and interface verification.

5.1.3.1 Experiment Performance Evaluation

The capability will be provided to enable investigators and specialists to monitor from the ground on-board experiments during selected time periods. In this manner, real-time consultation and assistance can be provided by the ground-based personnel.

In addition to this capability, scientific analysis laboratories will be provided to enable these ground experimenters to process specimens, run special tests, provide back-up laboratory analysis, and verify test conditions on the ground in support of the orbiting MSS experiments.

5.1.3.2 Experiment Communications

Experiment-related communications traffic between the MSS and the ground will be coordinated and controlled from the experiment operations support site. These communications will be in the form of hard data (tapes, notes, specimens, etc.,) and RF link transmissions (voice, video, digital data, command update, etc.,). Transmittal of hard data is basically a logistics and shuttle function, but the RF communications requirement establishes the need for a ground station and input/output terminals at this site.

5.1.3.3 Real-Time Down-Link Data Processing

A down-link data processing capability will be required at the experiment operations site to provide the displays required for real-time monitoring. Processing also shall be required to transform and dub data into formats and media that are comparable with the requirements of the data storage and distribution function.

5.1.3.4 Experiment Data Storage, Processing, and Distribution

The data generated by experiment-related activities, both in orbit and on the ground, will be routed to a central data facility. Functions performed at this site will be logging, sorting, dubbing per data-user specification, storage, and distribution to scientific investigators and other data users.

5.1.3.5 Experiment Package Integration and Interface Verification

The experiment packages will be assembled and acceptance-tested at the package level by the experiment integrator contractor. These packages will then be delivered to the MSV site for experiment and station integration tests and interface verification with the MSV.

5.1.4 MAJOR ASSEMBLIES AND FLOWS

The major assemblies and functional flows that are required for implementation of these capabilities at the experiment support center are shown in Figure 5.1-3.

5.1.4.1 Communications Interface

The experiment communications traffic between the MSS and the ground will be conducted through the same air-link utilized for normal station operations. Information transmitted will consist of digital information (commands, computer updates, and data), voice, and video. Typical mechanization of this concept is shown in Figure 5.1-4.

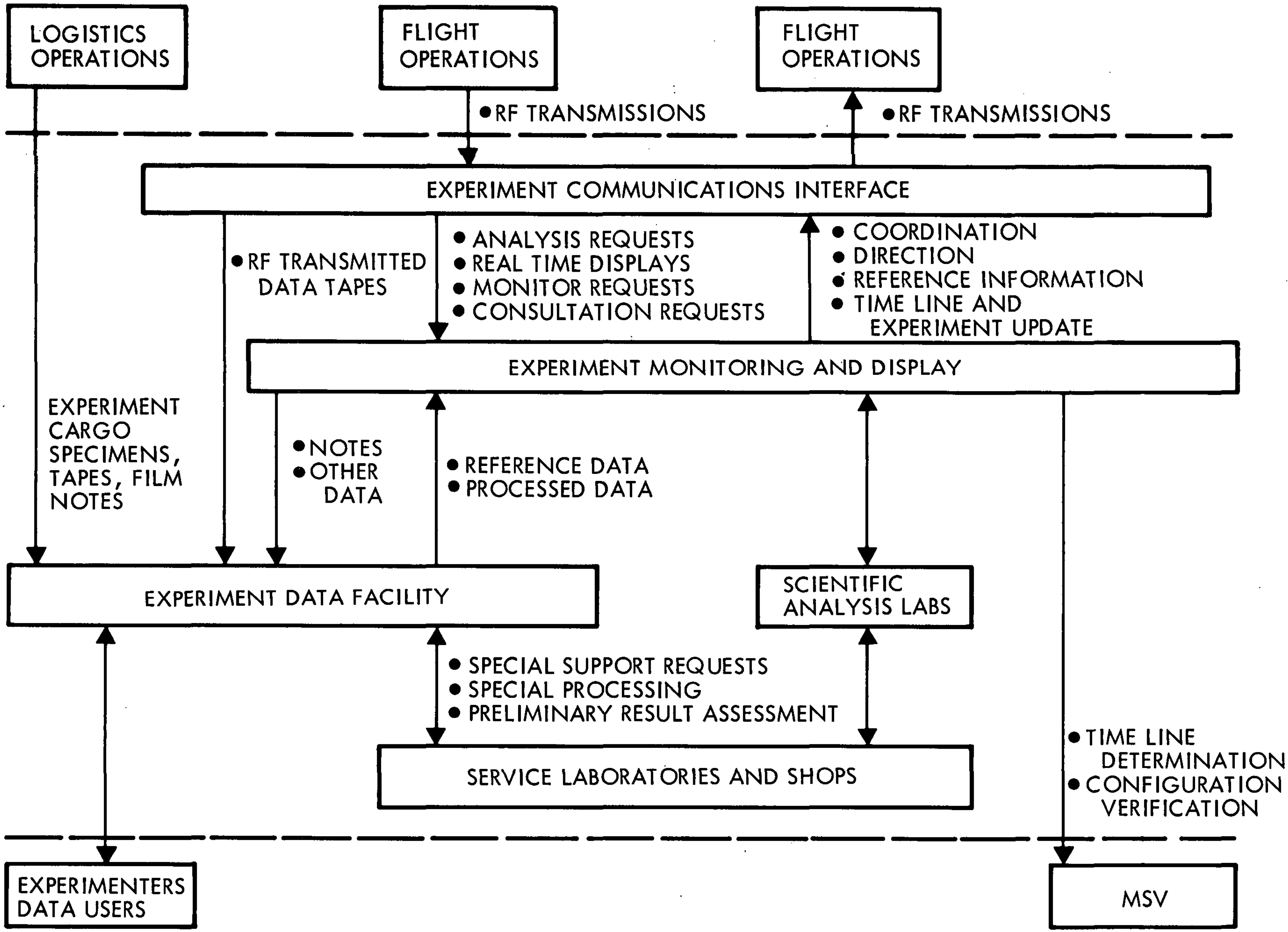

Figure 5.1-3. Experiment Ground Support

Responsibility for communications control is a function of the mission control center, but the experiment communications interface unit will perform functions, such as predetection recording, demodulation and decommutation, and processing of incoming information for distribution and display at the experiment operations site.

5.1.4.2 Monitor and Display

Experiment-dedicated consoles and/or group displays shall be provided to display down-link experiment data and reference information.

These monitoring capabilities shall include those listed in Table 5.1-2 and illustrated in Figure 5.1-4. In addition, up-link communications shall be provided through operational intercom and data transfer capabilities at the ground experiment monitoring site.

5.1.4.3 Experiment Data Facility

Capability shall be provided for receiving MSS-related experiment data for storing, cataloging, sorting, distributing, and servicing requests from data users. Data sources shall include both MSS experiment data and ground-generated reference information. Data types will include image and magnetic medium data, specimens, and notes delivered by the shuttle as

Table 5.1-2. Monitoring Capabilities

Display Characteristics	Display Instruments
Analog measurements	Oscillographs Meters CRT
Discrete events	Event lights Line printers CRT matrix
TV	CRT Large screen
Stills	CRT Large screen
Plots	CRT Large screen

well as recordings of RF transmissions from the MSS. The various functions and flows associated with this facility are shown by concepts in Figure 5.1-5.

A capability shall be provided to accommodate the following requirements:

1. Data sources and characteristics. The data to be received at the experiment data center will include:

   TLM data
   Computer data
   Teletype
   Facsimile
   Voice
   Hard data (laboratory notes, photographs, movie film, etc.)
   Specimens (material samples, animals, cultures, etc.)

2. Data storage. Provide secured and environmentally controlled facilities for the storage of the following types of data:

   Movie film
   Microfilm
   Negatives
   Slides
   Viewgraphs
   Audio tapes
   Video tapes
   Magnetic data tapes
   Paper data tapes
   Laboratory notes
   Books
   Reports

5.1.4.4 Service Laboratories and Shops

Laboratories and shops shall be provided to perform preliminary analysis and evaluation of MSS experiments. These laboratories and shops shall include both scientific analysis laboratories and processing shops for the various types of data generated by the MSS experiment program. The various operations included in these activities are shown in Figure 5.1-6. Characteristics and capabilities of these laboratories and shops are defined in the following paragraphs.

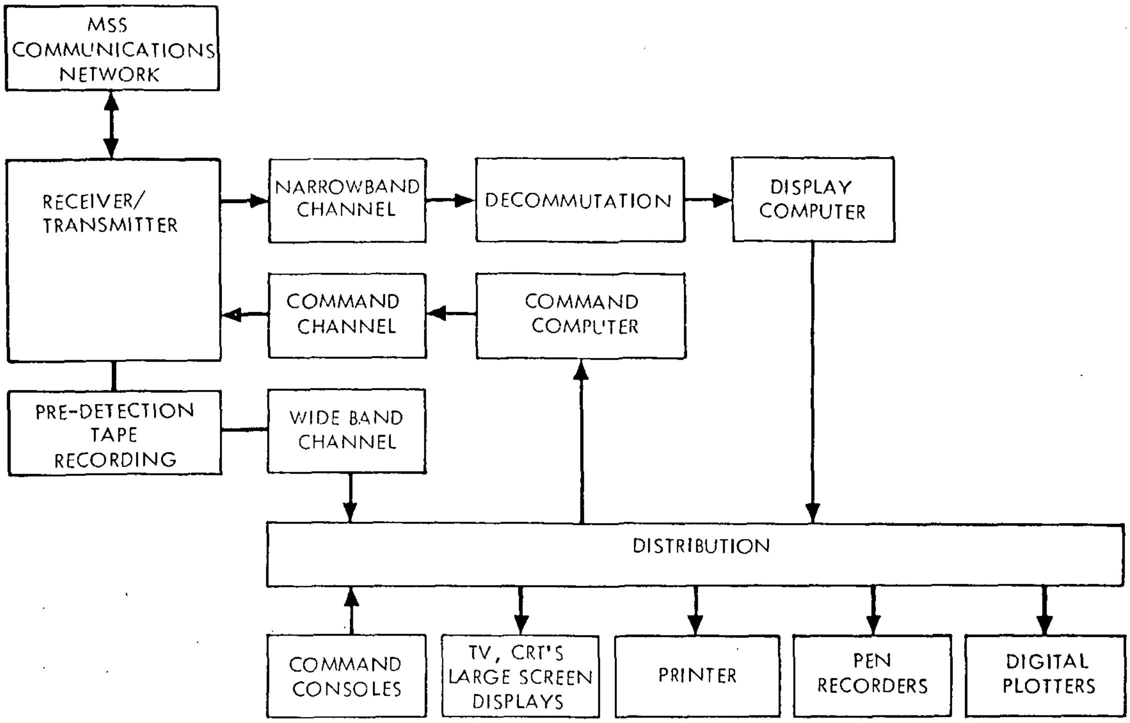

Figure 5.1-4. Communications and Data Transmittal Mechanization

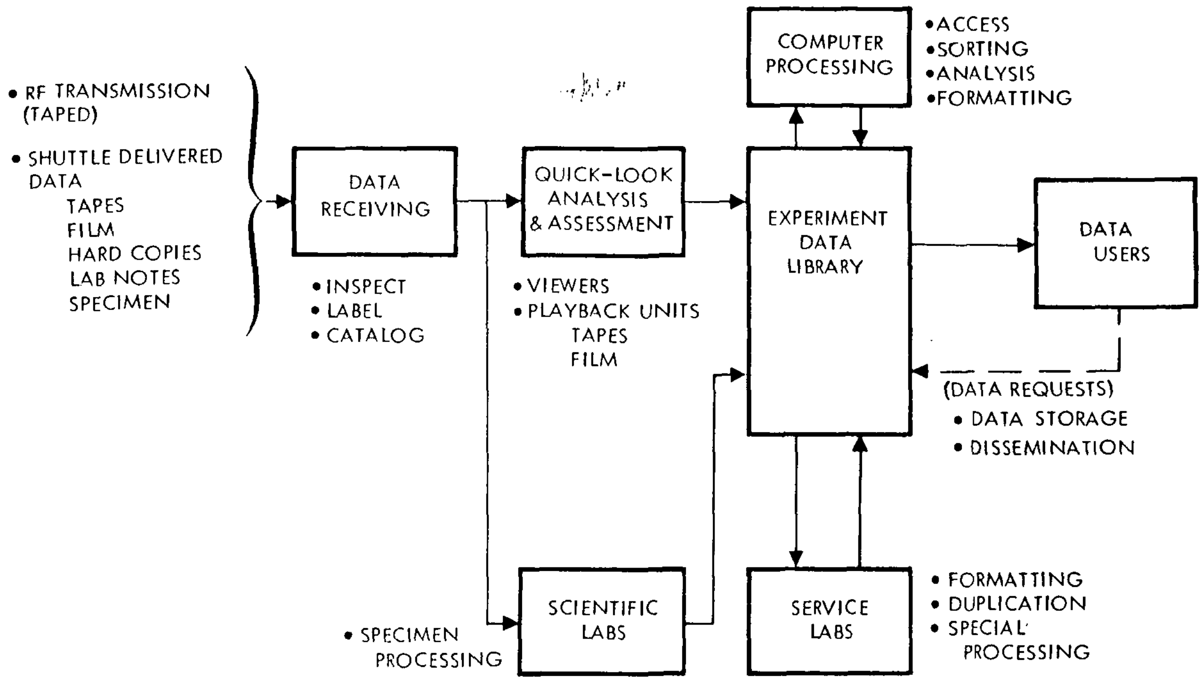

Figure 5.1-5. Data Processing Storage and Distribution

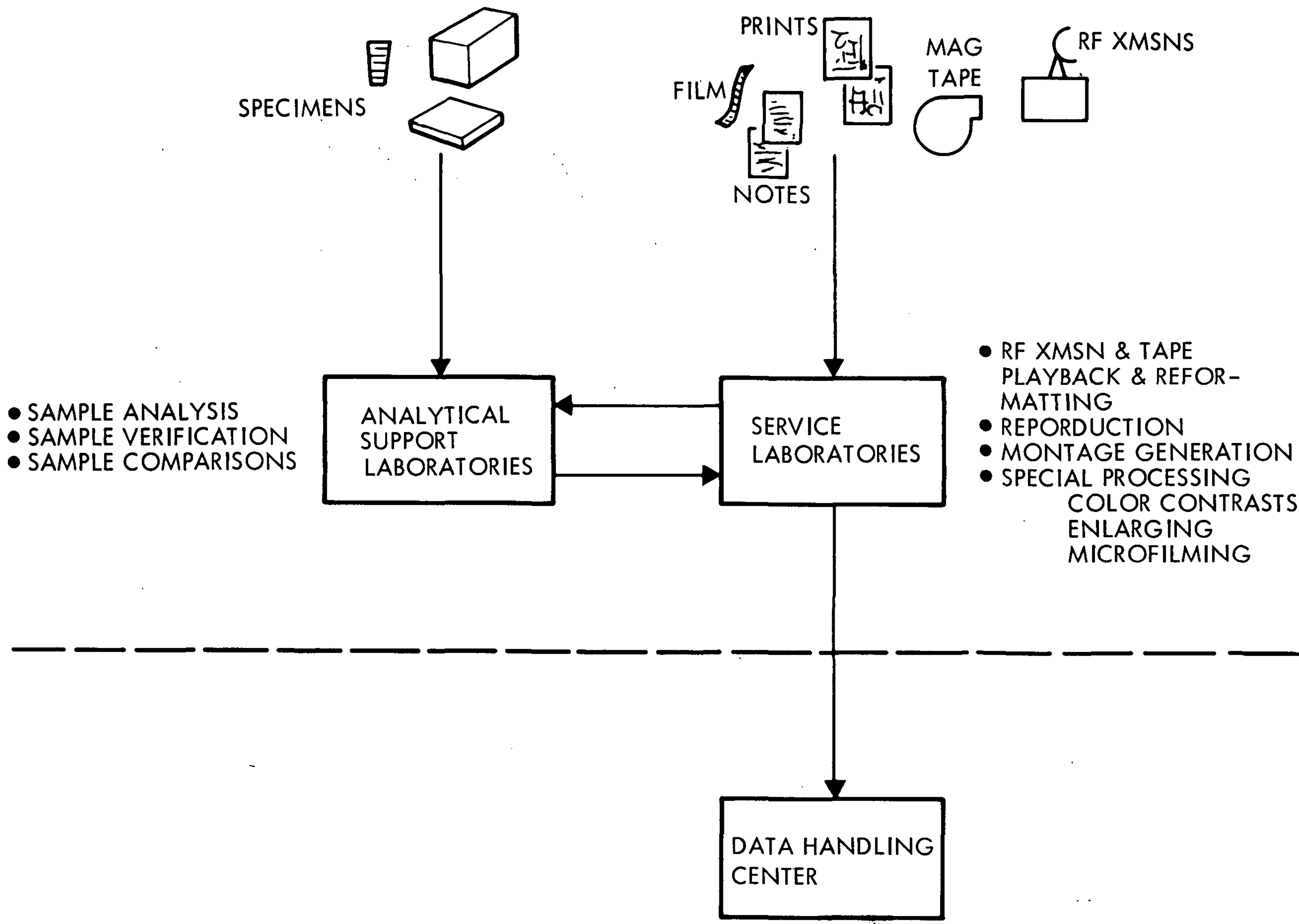

Figure 5.1-6. Laboratory Support Functional Flows

Analytical Support Laboratories

Laboratory facilities will be provided to perform preliminary assessment of experiment results and to support MSS experiments on a near real-time basis. The following laboratories shall be included:

1. Physiology laboratory.

   Building: Approximately 600 square feet, with high (15-ft) ceiling; 440-, 200-, 110-, and 28-volt outlets; a small sink with hot and cold water; gas; and temperature control

   Equipment: Ergometers
   Pulmonary function apparatus
   Respiratory gas analysis
   EEG
   EKG
   EMG
   Behavioral response equipment
   Oscilloscopes, visoscopes, etc

2. Genetics - embriology laboratory

   Building: Approximately 360 square feet, 200- and 100-volt outlets, hot and cold water, gas, distilled water, two sinks, temperature, and humidity control

   Equipment: EMT (table model electronic microscope)
   Light microscopes
   Dissecting scopes
   Incubating chambers
   Miscellaneous

3. Microbiology - invertebrate physiology laboratory

   Building: Approximately 600 square feet exclusive of walk-in incubators and cold rooms; 440-, 220-, and 110-volt outlets; hot and cold water; four to five sinks (30 ft by 48 in. by 15 in.); gas; distilled water; temperature - humidity control; and separate, sterilizable air-conditioning system

Equipment: Walk-in incubator (10 ft by 10 ft by 8 ft)
Walk-in cold room (10 ft by 10 ft by 8 ft)
Refrigerator - freezers
Incubators and ovens
Lyophilization apparatus
Light microscopes
Fluorimeters
Counters
Dissecting scopes
High-speed centrifuges (2)

4. Histology - pathology laboratory

Building: Approximately 360 square feet, 220- and 110-volt outlets, gas, hot and cold water, sinks (30 in. by 48 in. by 15 in.)

Equipment: Preparatory centrifuge
Ultra centrifuge
Clinical centrifuges
Spectrofluorimeter
Recording spectrophotometer
IR spectrophotometer
Gas chromotograph
Refrigerators and freezers
Incubators and roller tube devices

5. Botanical laboratory

Building: Approximately 360 square feet, high amperage 220- and 110-volt outlets, gas, hot and cold water, deep sink, separate air conditioning, temperature-humidity control 70 to 90 F, 100-percent relative humidity, and high-intensity light capabilities (80 to 800 foot-candles)

Equipment: Clinostats
Centrifuges
Microscopes, dissecting scopes, etc.

6. General support. In conjunction with the previously listed laboratories, the following satellite operations are required:

a. Offices and data reduction areas for each laboratory - 200 square feet each

b. Seminar room: 1200 square feet

c. Store rooms: Central 1600 square feet; 120 square feet each laboratory

d. Autoclave - dishwashing (with main store room): 400 square feet

e. Operating room: 360 square feet

f. Instrumentation room: 300 square feet

g. Animal holding facilities: 2400 square feet

h. Botanical hothouse or duplicate laboratory: 300 square feet

i. Isotope counting room: 160 square feet

j. Isotope storage and holding: 120 square feet (960 cubic feet) special instruction cellar

Equipment: Electron microscope, table model
Autoclaves, steam, and cryogenic gas
Operating room furnishings, table lights, etc
Mass spectrophotometer
Recorders
Scintillation counters
Beta detectors
Animal cages, etc
Dishwasher
ESR device
Remote manipulator devices

7. Physics/materials - analysis laboratories. Laboratory facilities will be provided to perform preliminary assessment of physics and materials experimentation in the orbiting space station and to provide experiment support in a near real-time basis. Capabilities provided will include provisions for:

Purifying
Vaporizing
Condensing
Freezing
Filtering
Mass and volume measuring

Hardness measuring
Tensile strength measuring
Thermal properties measuring

8. Optics laboratory. An optics laboratory and shop shall be provided to perform checkout calibration and maintenance of optical sensors and support equipment utilized in the EOSS program. Capabilities will include small optics alignment tables and large optics alignment tables.

Service Laboratories and Shops

A capability shall be provided to process and reproduce data generated in support of the MSS experiment program and will include the following laboratories and shops:

1. Photographic processes. Laboratories and shops at the experiment operations site will be used to perform the photographic services required to process photographic data delivered from the MSS by the shuttle and to provide data in various photographic formats to local and outside users. Services provided shall include:

   Still photography
   Motion picture filming
   Microfilming
   Developing
   Enlarging
   Reproducing
   Image enhancing
   Montage generation

   The following output formats shall be provided:

   Developed negatives - black and white, color
   Motion pictures - black and white, color
   Paper prints - black and white, color
   Slides
   Viewgraphs
   Microfilm

2. Audio-video processes laboratories. Laboratories and shops at the experiment operations site will perform the audio-video tape processing required to service the requirements of the orbiting space station and the data-users' requests. Services provided will include facilities for producing audio and video tapes, reviewing, editing, reproducing, and reformatting.

3. <u>Magnetic data tape laboratories</u>. Laboratories and shops at the experiment operations site will be used to perform the magnetic data type services required to process tapes delivered by the shuttle from the space station or tapes recorded locally from local activities or RD data dumps. Services provided will include facilities for playback and review, editing, reproducing, and formatting.

4. <u>Graphics and reproduction</u>. A graphics and reproduction capability shall be provided for the production of multiple copies of data and reports. Processes will include blue line, ozalid, and offset.

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5.2 SHUTTLE/MSV SITE OPERATIONS

5.2.1 SCOPE AND GENERAL REQUIREMENTS

Two MSS operational concepts that will have significant effects on KSC are (1) the total dependence on the shuttle for initial deployment, buildup,and logistics resupply and (2) the utilization of the MSV for system integration, interface verification,and as a system evaluation and qualification tool.

These concepts, together with the long operational life planned for the MSS, will necessitate the assignment to KSC of substantial responsibility for product support functions. This will include functions that, in present and past programs, have been the responsibility of contractor engineering and manufacturing operations.

Table 5.2-1 lists functions and activities in the previously mentioned categories; potential KSC involvement in each area is discussed in subsequent paragraphs.

5.2.1.1 Technical Management

The technical management function will include configuration control, engineering change management, quality and reliability, and resource allocation and scheduling.

The technical data required to define MSS program end-item configurations and interfaces, the development and processing of engineering changes, the implementation of quality and reliability standards, and the allocation and scheduling and resources will impose requirements on KSC. Primary areas of interplay between the technical management function and KSC will be derived from KSC's role in the processing of modules in preparation for launches and in the setup, operation, and maintenance of the MSV. For example, interface control documentation and procedures to define and ascertain module-to-module, module-to-shuttle, module-to-MSV, module-to-experiment, module-to-GSE, and module-to-facilities will have to be implemented at KSC. Also, quality and reliability functions will be required, such as inspections to verify hardware compliance to engineering drawings and specifications as well as nonconformance control system required to identify, document, and segregate and disposition nonconforming material. In this same area, KSC will perform reviews and will participate in the assessment and implementation of procedures affecting the design,

Table 5.2-1. Support Functions and Activities

1. Technical management

   Configuration control
   Quality and reliability
   Resource allocation and management
   Engineering change management

2. Engineering support

   Operations
   System performance evaluation
   Malfunction analysis
   Maintenance and refurbishment requirements definition
   Modification design and development

3. Manufacturing and shops

   Manufacturing liaison
   Manufacturing support shops
   Maintenance shops

4. Ground test facilities
   Mission support vehicle
   Calibration and standards laboratories
   Checkout laboratories

5. Maintenance logistics support

   Requirements analysis and inventory management
   Spares and consumables procurement, deployment, and maintenance

6. Crew and passenger processing

operation, quality, or safety of MSS, MSV, GSE spares, or facilities. The allocation and scheduling of resources will be an important concern of KSC because of its central role in the support and recycling of station and cargo modules. Facilities affected at KSC will include shops, GSE, facilities, and services as well as the required operational support personnel.

5.2.1.2 Engineering Support

Engineering support will include preflight analysis, mission and resupply planning, launch, and mission support.

During the station mission, systems data will be analyzed to assess actual and predicted system performance and will be compared to reference data derived from the MSV. Assistance also shall be provided for troubleshooting and fault isolation.

Performance assessments will be analyzed to forecast maintenance, refurbishment, and replacement of hardware. Requirements and specifications will be prepared and assistance will be provided for their implementation. Product improvement, problem resolution, and adaptation to updated mission objectives will require design changes and new hardware development.

The MSV as a configuration and control reference tool will figure significantly in the engineering support activities described. Thus, KSC will be intimately involved in providing this support and in implementing the concepts, designs, and plans developed as a result of the engineering support activity.

5.2.1.3 Manufacturing and Shops

Procurement of new or additional hardware and the modification, repair, maintenance, and refurbishment of spares and recycled hardware will require continuing manufacturing and shop capability. The location and the level of these capabilities will be constrained by the long-term duration of the MSS program, by rapid turnaround requirements, and by economic consideration that would tend to limit overall program manpower levels and communication and transportation lines.

Modification, repair, maintenance, and refurbishment activity of MSS and GSE hardware will involve in-operation items and spares inventory items located at the MSV and shuttle launch site. KSC will therefore be required to provide this type of support. This statement also recognizes that the MSV itself and the facilities/GSE required for prelaunch preparation will be required for retest and functional verification of these items.

5.2.1.4 Ground Test Facilities

An important facet of orbital operations support is the mission support vehicle (MSV). It will be an important tool for the determination of timelines, for the checkout and verification of interfaces and operation of new and refurbished or modified hardware and software, and it will provide a ground reference tool for use in MSS troubleshooting and fault isolation. The MSV operations will, in fact, be one of the primary MSS ground activities. Section 3.0 in this report deals solely with this particular ground test facility. The detail given in the following paragraphs is included to relate this facility to the other ground test facilities (i.e., the calibration and standards and checkout laboratories and shops required to qualify and certify the operational status of MSS hardware).

5.2.1.5 Maintenance Logistics Support

The maintenance and logistics support concept for the MSS includes provisions for the performance of (1) support requirements analysis, (2) maintainability analysis, (3) inventory management, (4) technical support documentation, and (5) operational support as they relate to the procurement, storage and deployment, and repair and modification control of spares, consumables, GSE, and other support resources and services required by the modular space station. Maintenance will be performed at one of the levels defined below:

Level I. Maintenance activities accomplished in-flight to prevent or correct a malfunction

Level II. Maintenance activities performed to repair an in-flight replaceable unit after it has been returned to the operations site. Successful repair of a unit at this level will result in its return to an operational spare status.

Level III. Maintenance activities that are in effect extensive rework, repair, and refurbishment of returned units that require specialized skills, equipment, or facilities. KSC will require a Level II maintenance capability in order to minimize ground turnaround times and to utilize the checkout capabilities provided by the MSV installation. This concept will involve KSC operations both for data base creation and maintenance and for its utilization.

Requirements Analysis and Inventory Management

The potential effect on KSC by the identified maintenance and logistics tasks and documentation are listed below:

1. Support requirements analysis. The identification of the resources required to accomplish the maintenance and logistics functions will be a joint effort by the various disciplines of logistics, maintenance, GSE, and design. The KSC launch site will participate in the determination of these requirements to identify specific techniques or requirements and to integrate, wherever possible, the utilization of GSE and facilities between shuttle and MSS operations.

This analysis will identify and describe the following:

a. Required maintenance tasks, sequence, and location

b. Spares, consumables, and other materials required to perform the tasks

c. Type and quantity of personnel required to perform the tasks

d. Support documentation required

e. Maintenance facilities required

Final decisions will be based on program level tradeoffs that will take into consideration efficient utilization of existing capabilities and economic and operational advantages of specific locations such as shuttle or the MSV site.

2. Maintainability analysis. There are two basis maintenance decisions considered: in-flight and ground. The primary driver in the maintainability analysis is to assure that the design and installation of subsystems and components can be maintained within the constraints of crew and subsystem operations. However, the analysis will include a determination of ground maintainability considerations. For example, special access, handling equipment and procedures will be identified. Another example would be the identification of the MSV ISS as a necessary tool for troubleshooting and fault isolation.

Other objectives of this analysis are to define the following for their effect on KSC operations:

a. Complexity of maintenance tasks

b. Need for scheduled maintenance

c. Maintenance down-time

d. Potential for maintenance error

e. Post-maintenance checkout

It should be noted that these maintenance characteristics will influence the nature and level of maintenance capability required at the shuttle/MSV site, especially as they affect turnaround times and MSV utilization.

3. Inventory management. A controlled material acquisition system will be established for the fabrication and/or procurement of spares, consumables, and other technical operating supplies that are required for the continuance of the space station mission over its total life cycle.

   The optimum system should maintain accountable property records in a computerized information system for effective, rapid, and accurate access to the records relating to procurement, allocation, inventory usage history, and stock position. This inventory management system shall be integrated with the common data base and with the MSS information system to provide the algorithms and data base necessary to store the information and generate the reports required for the control and scheduling of the following activities:

   a. Shipment, receipt, storage, and distribution of spares

   b. Maintenance of accountable property records

   c. Identification of the replaceability and repairability of spares

   d. Processing of station module and GSE components for repair refurbishment and modification

   e. Transaction reporting for stock management

   f. Inventory maintenance including control of shelf-life requirements, calibration, cleaning, environmental control, and packaging

   KSC involvement will be both as a user and a contributor to the generation and maintenance of the inventory management system. Input/output capability to the system will be required by the stores and warehouses located at KSC for servicing the shuttle logistics flights and the MSV and GSE maintenance and repair activity. A functional flow diagram of these activities is included in Figure 5.2-1.

Spare and Consumables Procurement, Deployment,and Maintenance

Technical Support Documentation. Technical support documentation will be developed to furnish descriptive and procedural data pertaining to ground and MSS flight hardware maintenance and operation. This documentation will be used for crew training, ground equipment maintenance, and

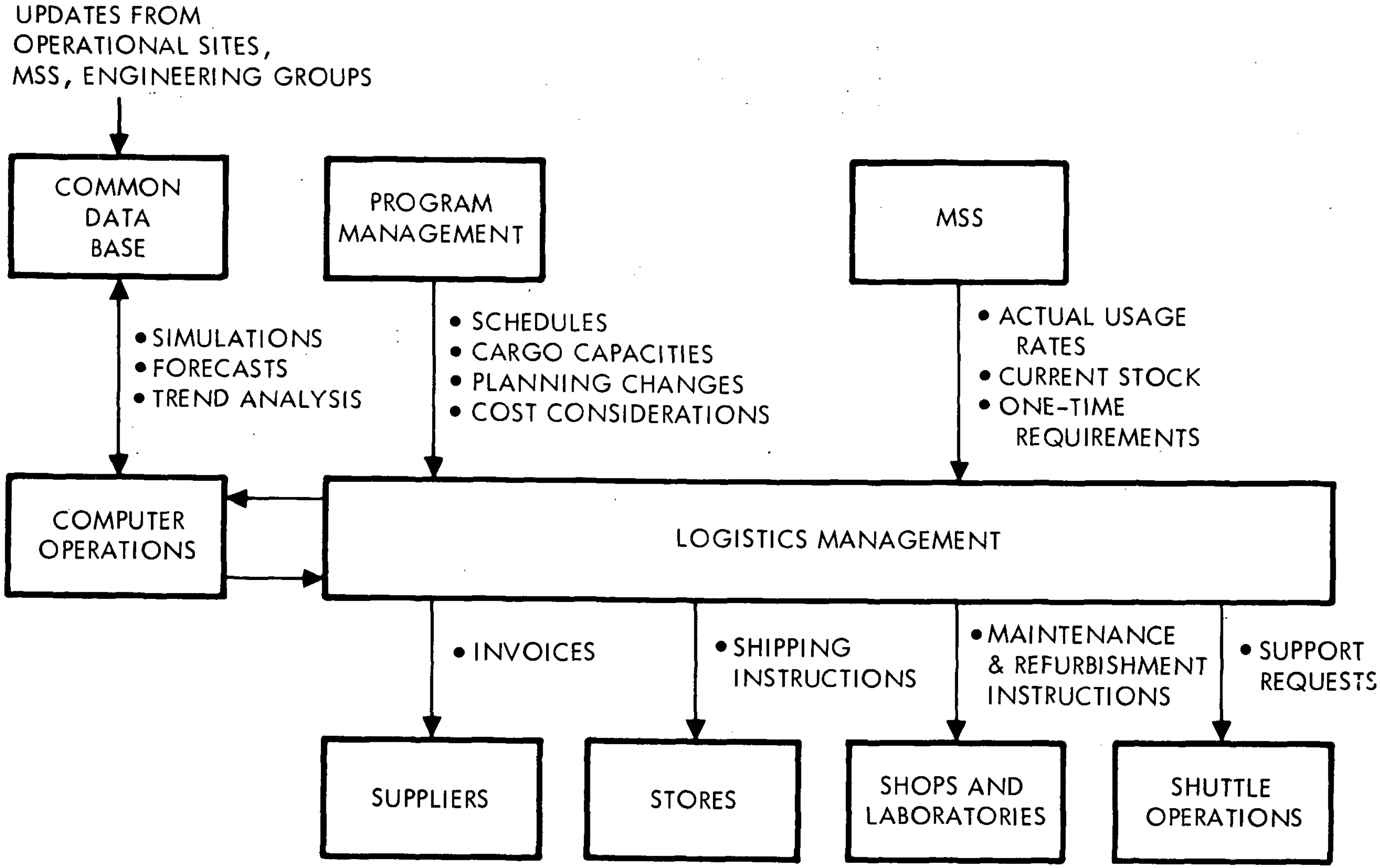

Figure 5.2-1. Inventory Management Functional Flows

MSS maintenance. KSC inputs shall be required for sections of this documentation to incorporate technical or program constraints or flexibilities required for effective implementation at this site. Documentation presently identified are:

1. Orbital operations requirements

2. Subsystems maintenance manuals

3. Support equipment maintenance requirements

4. Component repair instructions

5. Modification instructions

In latter phases of the program, KSC inputs will be required to incorporate the experience gained through operation of the MSV and the maintenance, modification, and repair of MSS hardware.

Test Support. This function includes the quantification of MSS and GSE test and operational support spares based on expected usage and repair capabilities at the user location, the acquisition of test support equipment, and the management of the inventory assets to assure the availability of equipment and the management of the inventory assets to assure the availability of equipment. During the initial phases of the MSS program, the test support will be focused on development-type testing, such as structural testing, dynamic testing, compatibility assessment, and acceptance testing. Later, however, the emphasis will shift to the shuttle/MSV site, and the primary test support effort will be based at KSC and will be phased over to an operational support function as described in the following paragraphs.

Operational Support. The transition from a test and development phase to an operational support operation will be particularly important to KSC. Test support will be provided at KSC during the development and prior to the launch of the initial station modules. This test support will be retained at KSC during the total life-cycle of the MSS to accommodate acceptance of growth modules, RAM's, and cargo modules. They will, however, attain operational support characteristics as the program progresses into the initial and growth phases of the MSS life cycle. During this period, KSC will in fact be the operational support center with principal responsibility for interfacing with the MSS through the shuttle. Operational and test support in the context of logistics operations will include the provisioning, warehousing, and maintenance and repair control of spares and consumables.

5.2.1.6 Crew and Passenger Processing

Crew and passenger processing at the shuttle/MSV site will provide temporary quarters and provisions for familiarizing this personnel with MSS configuration and hardware characteristics.

5.2.1.7 Requirements Summary

The general requirements discussed previously will have an effect on operational management, manpower skills, and on facilities/GSE at KSC as shown by the summary chart in Table 5.2-2. It must be recognized, however, that the engineering and other technical tasks at the shuttle/MSV site will be complex and diversified. Personnel requirements call for professionally competent personnel with experience not only in vehicle test but also in design, analysis, and technical management. To be cost-effective, consideration must be given to integrating these various facets of space station processing at KSC and in some cases integrating them with shuttle requirements.

The facilities and GSE requirements may be discussed in terms of (1) engineering office space and (2) test and processing facilities. The major test and processing facilities are discussed in Section 5.2.2.

Table 5.2-2. Manpower Skills—Logistics and Support Engineering

SHUTTLE/MSV SITE FUNCTIONS	SKILLS			OPERATIONAL MANAGEMENT		FACILITIES AND OTHER RESOURCES						
	ENGINEERING	TECHNICAL	CLERICAL	ORGANIZATIONAL STRUCTURE	PROCEDURES	SCIENTIFIC LABORATORIES	SERVICE LABORATORIES	MANUFACTURING AREAS	WAREHOUSES	COMPUTER INSTALLATIONS	TRANSPORTATION	MSV
1. TECHNICAL MANAGEMENT	X	X	X	X	X							
2. ENGINEERING SUPPORT	X	X			X	X	X			X		
3. MANUFACTURING		X	X		X			X			X	
4. GROUND TEST	X	X			X	X	X			X		X
5. LOGISTICS	X	X	X		X				X	X	X	
6. CREW/PASSENGER												X

5.2.2 FACILITIES AND GSE REQUIREMENTS

The support requirements discussed in the previous sections infer certain facilities and GSE capabilities at KSC. These consist of:

- Computer installations
- MSV
- Maintenance, modification, and refurbishment shops
- Warehouses
- Transportation
- Service laboratories

5.2.2.1 Computer Installations

Local computers and terminals for access to remotely located computers shall be required to assist in the performance of engineering analysis and inventory management.

Engineering Analysis

General purpose computers shall be available for use in the analysis of system performance and mission characteristics based on trend data developed from the mission support vehicle and from data relayed to the site by the flight operations function.

Inventory Management

The complexity, size, and duration of the MSS and its mission will necessitate the implementation of a computer-based inventory management system. The data base requirements for the logistics system will be integrated with the common data base that will be developed for the modular space station program. This common data base will contain, in addition to the strictly logistics related information on the MSS, information required for performance of other functions, such as design, test and checkout, performance assessment, and configuration control. The common data base depository or storage banks may be physically located remotely to the MSV/ shuttle site. However, because of this site's central relationship in the flow of supplies to the MSS, it will have to have computers, terminals, and programs to access the common data base and to implement the inventory management system.

5.2.2.2 Mission Support Vehicle

The MSV facilities and installation requirement, utilization, and operational characteristics are discussed in Section 3.0.

5.2.2.3 Maintenance, Modification, and Refurbishment Shops

Shops will be required at the logistics support site to perform calibration, refurbishment, and maintenance of space station spares. A capability also shall be provided to perform repairs and modification of spares and returned MSS hardware.

The facilities required shall consist of electrical, electronic, optical and mechanical (fluids and pneumation), laboratories, and shops.

Electrical and Electronic Shop. This facility will include an RF room, measuring devices, signal generators, monitoring equipment, power supplies, and other bench-type test equipment.

Mechanical Shop. The facilities provided shall include FPE assembly and disassembly capabilities, clean rooms, machine shops, cleaning shops, surface treatment shops, and pneumatic sources.

Optics Shop. Clean rooms, optical benches, and light sources shall be provided at the logistics site to provide for checkout and calibration of telescopes, cameras, and other optical instruments utilized in the MSS mission and experiment program.

5.2.2.4 Stores and Warehouses

The logistics operations site will have provisions to store perishable and nonperishable items as determined necessary to provide temporary storage of up- and down-experiment cargo such as gases, specimens, and data storage consumables (magnetic tape, film, etc.,).

Cryogenic Storage

Tank farms and associated facilities shall be provided to store the following types of cryogenics:

LHe	LN_2
LH_2	LHe
LO_2	Miscellaneous

Gases

Tank farms and associated facilities shall be provided to store the following types of gases:

Argon	O_2
He	N_2

Ne	Calibration gas
CO_2	Miscellaneous

Spares

Environmentally controlled and secured facilities shall be provided for the storage of MSS IFRU's and GRU's. These facilities shall meet TBD humidity, cleanliness, and temperature requirements. These IFRU's and GRU's shall be packaged as follows:

	Size	Weight
IFRU's	TBD	TBD
GRU's	TBD	TBD
Experiment packages	TBD	TBD

Miscellaneous

Storage facilities for the following types of supply items shall be provided:

- Food
- Water
- Clothing
- Medical and dental supplies
- Recreational items
- Photographic supplies
- Magnetic tapes
- Specimens:
  - Materials and gases
  - Plants
  - Animals
  - Other biological specimens

Personnel and station-keeping resupply requirements are listed in Figure 5.2-2 for a 30-day resupply schedule. Experiment resupply requirements are shown in the figure as estimated at 1000 pounds per month. Typical items included in this figure are listed in Table 5.2-3.

5.2.2.5 Transportation and Handling

This assembly shall consist of the tractors, platforms, handling rings, and other devices required to unload cargo upon arrival at the logistics site, to transport it to the storage facilities and/or to the shuttle cargo loading site, loading into a cargo module if required, and finally into the shuttle cargo bay. Similar activities will be performed during down-cargo operations.

LOGISTICS ITEM	RESUPPLY REQUIREMENT (LB/30 DAYS)	
	INITIAL	GROWTH
CLOTHING	76	152
LINENS	62	124
GROOMING	10	20
MEDICAL	15	30
UTENSILS	56	112
FOOD	650	1300
GASEOUS		
STORAGE – O_2	3	3
– N_2	247	377
WATER	369	716
SPECIAL LIFE		
SUPPORT LiOH	10	10
WATER MANAGEMENT	40	81
ATMOSPHERIC		
CONTROL	217	434
CO_2 MANAGEMENT	57	113
WASTE MANAGEMENT	27	53
HYGIENE	11	21
SPARES	34	69
SUBTOTAL	1884	3615
AVERAGE EXPERIMENT RESUPPLY	1000	1800
TOTAL 30-DAY AVERAGE	2884	5415
UP-DOWN EMERGENCY (96 HR) O_2	404	633
H_2	23	36
TOTAL EMERGENCY	427	669

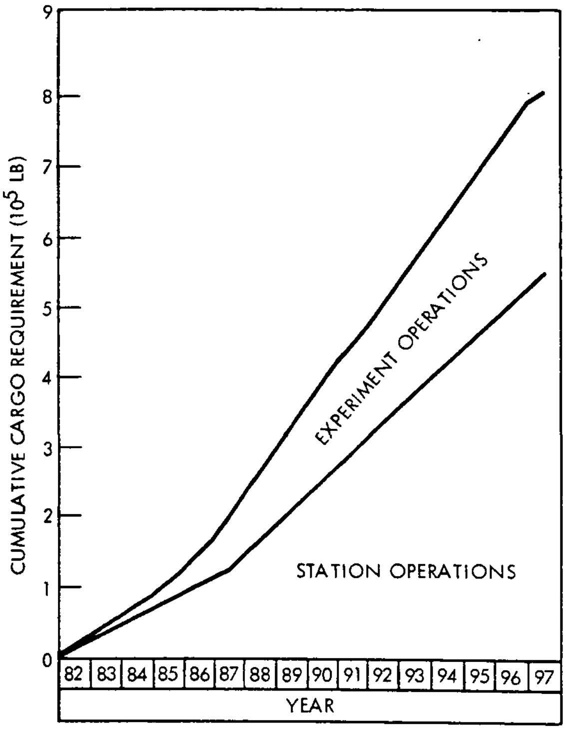

Figure 5.2-2. Up-Cargo Requirements

Table 5.2-3. Experiment Consumables Requirements Summary

Consumable Item	Consumable Item
Liquid helium	Film
Liquid hydrogen	Photo-processing chemicals
Liquid neon	Emulsion
Liquid nitrogen	Laboratory supplies
Cryogenics (TBD)	Waste management chemicals
Water (NMIC)	Chemicals (TBD)
Water (STD)	Tapes
Water (animal)	Logs
Gaseous helium	Micrometeoroid collector
Gaseous neon	Balloon
Gaseous nitrogen	Faraday cups
Gaseous oxygen	Langmuir cups
N_2/O_2 atmosphere at 1500 psi	Animal food
Argon	Culture
Hydrazine	Spares, specimens, samples
Gas (TBD)	

5.2.2.6 Service Laboratories

A capability shall be provided to process and reproduce data generated in support of the MSS mission. The following laboratories and shops capability shall be included:

1. Photographic process laboratory. The MSV/shuttle site shall have laboratory and shop capability to provide the photographic services required to process photographic data delivered from the MSS by the shuttle and to provide data in various photographic formats to local and outside users. Services provided shall include:

   Still photography
   Motion picture filming
   Microfilming
   Developing
   Enlarging
   Reproducing

   The following output formats shall be provided:

   Developed negatives - black and white, color
   Motion pictures - black and white, color
   Paper prints - black and white, color
   Slides
   Viewgraphs
   Microfilm

2. Audio-video processing laboratories. Laboratories and shops at the MSV/shuttle site will perform the audio-video tape processing required to service the requirements of the orbiting space station and local engineering data requests. Services provided will include:

   Producing audio and video tapes
   Reviewing
   Editing
   Reproducing
   Reformatting

3. Magnetic data tape laboratories. Laboratories and shops at the shuttle/MSV site will be used to perform the magnetic data type services required to process tapes delivered by the shuttle from the space station or tapes recorded locally from local activities or RF data dumps. Services provided will include facilities for:

Playback and review
Editing
Reproducing
Formatting

4. Graphics and reproduction shop. A graphics and reproduction capability shall be provided for the production of multiple copies of data and reports. Process will include blue line, ozalid, and offset.

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5.3 KSC IMPLEMENTATION PLAN AND CAPABILITY ASSESSMENT

The final selection of specific KSC facilities to support the operations described will have to take into consideration the capability that will have been developed at KSC to support the space shuttle. However, it is feasible to extrapolate present uses of existing facilities and to postulate their use for similar applications for the MSS. In this manner a preliminary assessment of KSC's capability on the area of MSS operations support can be performed. There are various documents in existence that describe KSC facilities; six of these documents are listed in Table 5.3-1. A brief search of these documents was performed to identify potential MSS orbital operations support facilities. A list of the candidate facilities is given in Table 5.3-2 along with a brief description of their present usage and/or capability.

Table 5.3-1. KSC/AFETR Description Documents

Document Title	Prepared By
Facilities Description KSC/AFETR	Space Shuttle Task Group
GP-914 - Support Operations Handbook	Support Operations Directorate
Space Shuttle	
KSC Real-Time Data Reduction and Display System	Director of Information Systems
Olds System Description	G.E. Apollo Systems Dept., Kennedy Operations
MSC-02463-33-Ft-Dia Station KSC Launch Site Support Definition	Space Division, North American Rockwell Program Engineering

In comparing these various facilities with the requirements discussed in the previous sections, it is apparent there are several options for implementing the MSS operations support capability at KSC. These options are

Table 5.3-2. KSC Facility Option Capabilities

Facility	Capability Summary
MSO - O&C Building	Test areas, low bay, high bay Transitory crew quarters Control center - control rooms (display, command) Computers, RF receiving station, quick-look data Laboratories - Biomedical Materials Clean rooms Altitude chambers
CIF	Laboratories - calibrations, standards, clean room Computation scientific (GE-635 system) Communications station (data, audio, video) TLM Operations support room Computation administrative (IBM 360 system)
Flight Crew Support and Training Building	Libraries Computers Experiments Training
Spacecraft Spares and Equipment Building	Maintenance Modifications Shipping Receiving Processing, storage
Communications Distribution and Switching Center	Interfacility and intrafacility communications
Central Supply	Controlled storage Control of parts
Headquarters Building	Administration Photography Reproduction Library
VAB High Bay	Shops Laboratories

Table 5.3-2. KSC Facility Option Capabilities (Cont)

Facility	Capability Summary
VAB Low Bay	Shops Labs Clean rooms Administration
Launch Control Center	Firing rooms Telemetry stations
Launch Pads	Cryogenic storage (LO_2, LH_2, LN_2, GN_2, GHe, GH_2, LN_2, LH_2) High-pressure gas storage
Converter/Compressor Facility	Liquid cryogenics to 6000-psig GN_2 and GHe
Propellant Laboratory and High-Pressure Maintenance Facility	Maintenance of high-pressure equipment
Contractor Support Building	Light duty machine shop
Unified S-Band Facility	
Warehousing and Storage (500,000 sq ft)	55,000 is air-conditioned 150,000 air-conditioned

indicated in Table 5.3-3. Also shown in the table is a recommended implementation plan based on the following considerations:

1. Clear superiority of one facility over the others in terms of existing capability in the specified support area.

2. Present utilization of facility for applications similar to those required in support of the MSS.

3. Selection contributes to maintaining related activities in continuous locations.

4. Other facilities were selected to satisfy alternate requirements.

In summary, the utilization of KSC facilities shown in Figure 5.3-1 provides a feasible baseline for implementing ground support for MSS orbital operations.

Obviously, further analysis and definition of these ground operations is required particularly in the areas of experiment package processing and in experiment data management and distribution. Studies are at present in various stages of procurement to provide this definition. Subsequent reevaluation of KSC's role in these areas to incorporate the findings of these studies is clearly indicated.

Table 5.3-3. Candidate and Selected Facilities for Mission Operations

Facility / Operation	Flight Operations	Display/Control	Ground Station & IU	Data Processing	Experiment Operations	Experiment Monitor and Control	Laboratories and Shops	Experiment Data Center	Logistics Operations	Warehouses and Stores	Transportation and Handling	Logistics Control	Engineering Support	Tech Management	Design Support	Integration Tool	Crew/Passenger Processing	Electromechanical Shops
MSO O&C Building																		
Test area (high and low bays)																X		
Transitory crew quarters																	O	
Control centers - ACE		X		X		X												
QLDS		X				O												
RF ground station			X															
Laboratories - Biomedical							O											
Materials							O											
General purpose							O											
General purpose areas								O						X	X			
Central Instrumentation Facility																		
Laboratories - Calibration and standard clean rooms							X											
Scientific computation - GE-635				O		O												
Administrative computation - IBM360								X										
Control room (Rm 307)		O																
Ground station			O			O												
Flight Crew Support and Training																		
Spacecraft Spares and Equipment Building																		
Maintenance and modifications																	O	
Shipping, receiving										O	O							
Storage										O								
Communication Distribution and Switching																		
Interfacility/intrafacility communications			X															
Central Supply																		
Controlled storage										O								
Headquarters Building																		
Administration								X						O	O			
Photography							O											
Reproduction							O											
Library																		

Table 5.3-3. Candidate and Selected Facilities for Mission Operations (Cont)

Facility \ Operations	Flight Operations	Display/Control	Ground Station & IU	Data Processing	Experiment Operations	Experiment Monitor and Control	Laboratories and Shops	Experiment Data Center	Logistics Operations	Warehouses and Stores	Transportation and Handling	Logistics Control	Engineering Support	Tech Management	Design Support	Integration Tool	Crew/Passenger Processing	Electromechanical Shops
Warehouses and Storage																		
Air-conditioned										O								
Ambient air										O								
Vehicle Assembly Building	Shuttle operations																	
High bay																		
Low bay																		
Mechanical shops																		
Clean rooms																		
LC-39 Launch Control	Shuttle operations																	
Control rooms																		
Telemetry station																		
Facility instrumentation																		
LC-39 Launch Pads																		
Cryogenic storage																		
High-pressure gas storage																		
Converter Compressor Facility																		
Propellant Laboratory and High Pressure Maintenance Facility																		X
Contractor Support Building																		
Light duty machine shop																		O
MILA Ground Station			X															

O Selected facility for function

X Candidate

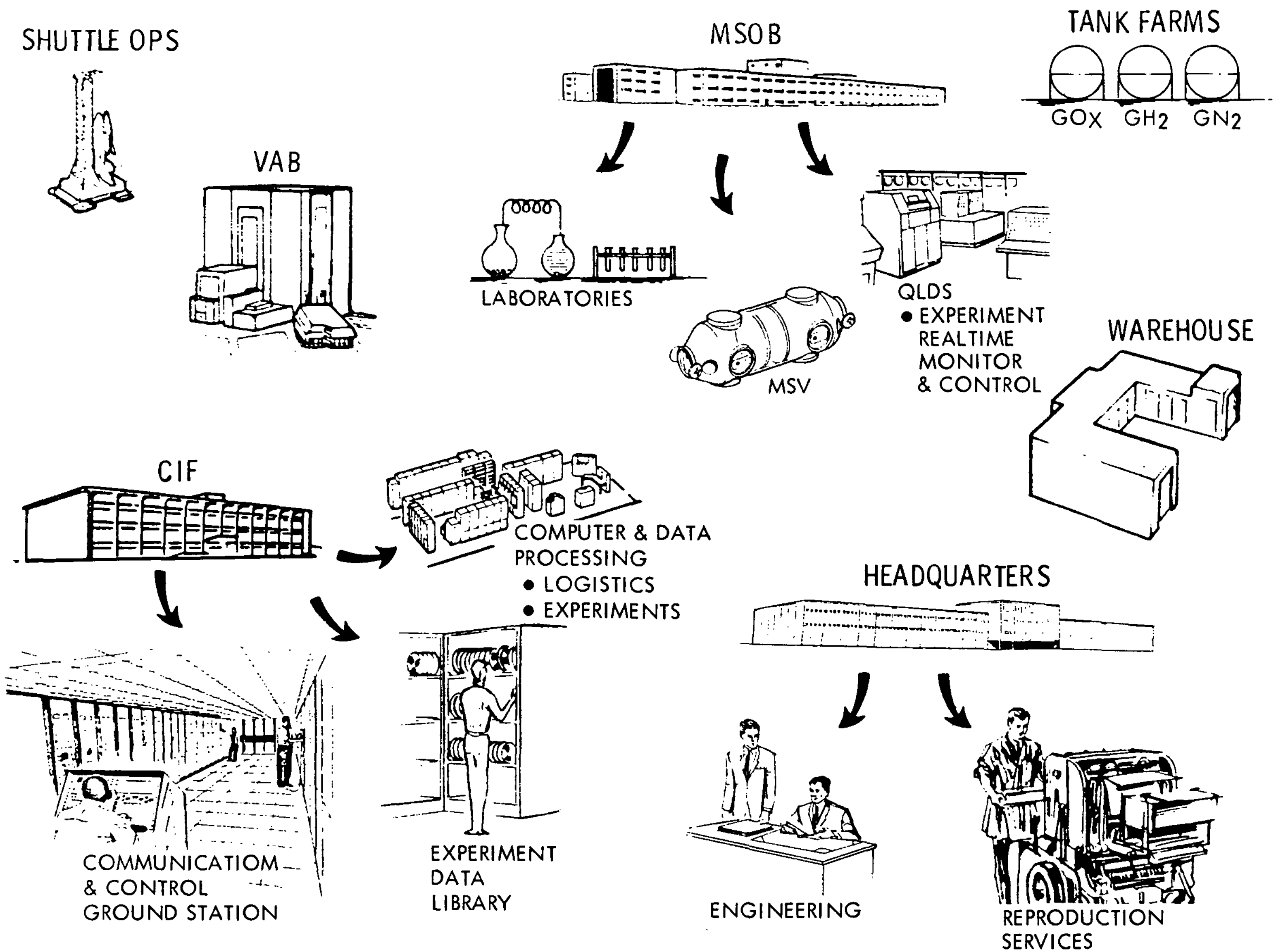

Figure 5.3-1. KSC Support Capabilities