NOVEMBER 1981

MDC G9744

SECOND INTERIM BRIEFING (DR-3)

EVOLUTIONARY SCIENCE AND APPLICATIONS SPACE PLATFORM (CHARACTERIZATION OF CONCEPTS) (TASKS A AND B)

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY

MCDONNELL DOUGLAS CORPORATION

(NASA-CR-173521) SECOND INTERIM BRIEFING (D3). EVOLUTIONARY SCIENCE AND APPLICATIONS SPACE PLATFORM. CHARACTERIZATION OF CONCEPTS, TASKS A AND B (McDonnell-Douglas Astronautics Co.) 192 p HC A09/MF A01 G3/18

N84-23671

Unclas 13142

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MCDONNELL DOUGLAS ASTRONAUTICS COMPANY-HUNTINGTON BEACH
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PREFACE

This document contains material prepared by McDonnell Douglas Astronautics Company* for the Second Interim Briefing on a Characterization of Concepts for an Evolutionary Science and Applications Space Platform as defined in the Statement of Work for Contract NAS8-33592 by Marshall Space Flight Center, where the contact is:

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*Hamilton Standard has been given a $5000 subcontract for provision of selected ECLSS concepts and data.

STUDY OBJECTIVES

Define, Evaluate, and Select Concepts for Evolving:

- A Space Station in Conjunction with the Space Platform for NASA Science, Applications, Technology ($250K) and, DoD ($140K)
- A Permanently Manned Presence in Space Early, with a Maximum of Existing Technology

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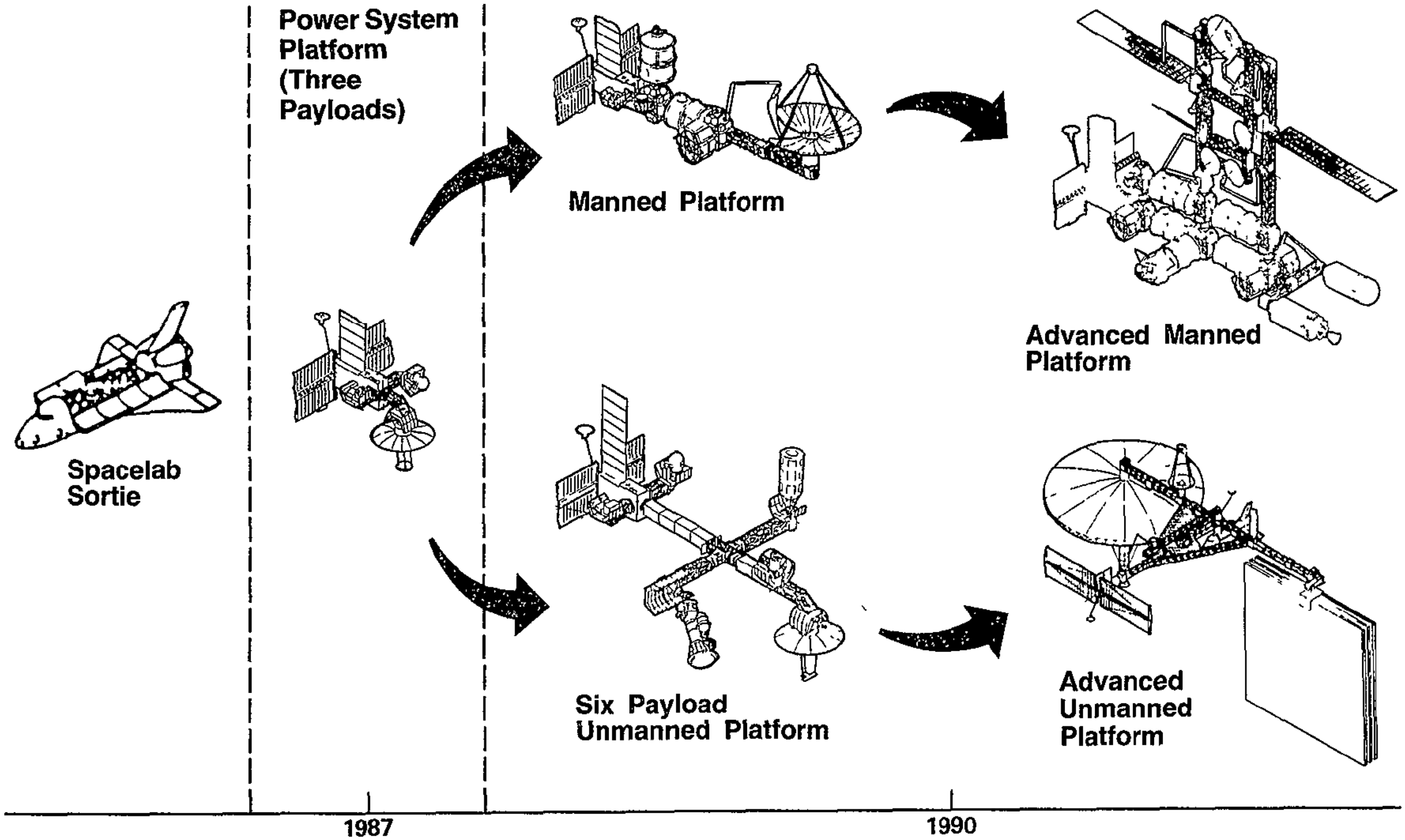
SPACE PLATFORM EVOLUTION



STUDY TASKS

A. Special Studies of Unmanned Platform in Areas Highlighted in Prior Study ($50K)

- Innovative Basic Concepts
- Control System Dynamics
- Payload Accommodation Assessment

B. Conceptual Definition of Manned Platform ($250K)

- Requirements and Candidate Concepts
- Systems Analysis and Definition
- Comparisons, Programmatics, and Selection

VFM284N

AGENDA

Study Overview	Fritz Runge
Special Unmanned Platform Studies (Task A)	
Manned Platform Concept (Task B)	Fritz Runge
■ Configuration, Structural/Mechanical and Operations	
■ System and Payload Requirements, and Performance	Dave Riel
■ Subsystems, Habitability, and Safety	Bill Nelson
■ Programmatics	Denny Niblo

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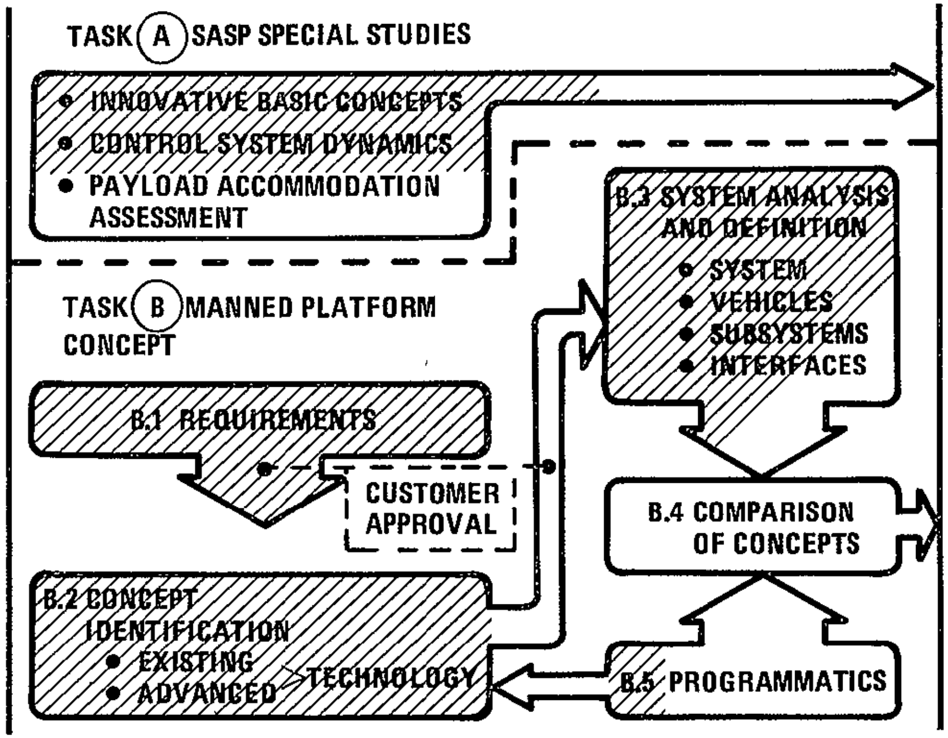
STUDY TASK FLOW

INPUTS

- SASP STUDY RESULTS
- POWER SYSTEM DEFINITION
- SASP PAYLOAD ACCOMMODATIONS ASSESSMENT
- SPACELAB ϕB FOD DEFINITION
- STS HANDBOOKS AND PLANS
- MSFC IN-HOUSE STUDIES ON MANNED PLATFORM



OUTPUTS

- INNOVATIVE SASP CONCEPTS, DYNAMICS AND P/L ACCOMOD
- REQUIREMENTS FOR MANNED PLATFORM
- CANDIDATE CONCEPTS
- DEFINITION OF COST EFFECTIVE APPROACH TO EVOLVING MANNED PLATFORM
- TRADES AND ANALYSES
- WBS, COSTS AND SCHEDULES
- SYSTEM INTERFACES
- PHYSICAL CHARACTERISTICS
- IMPACT OF REPRESENTATIVE MISSIONS ON:
  - POWER SYSTEM
- TECHNOLOGY REQUIREMENTS

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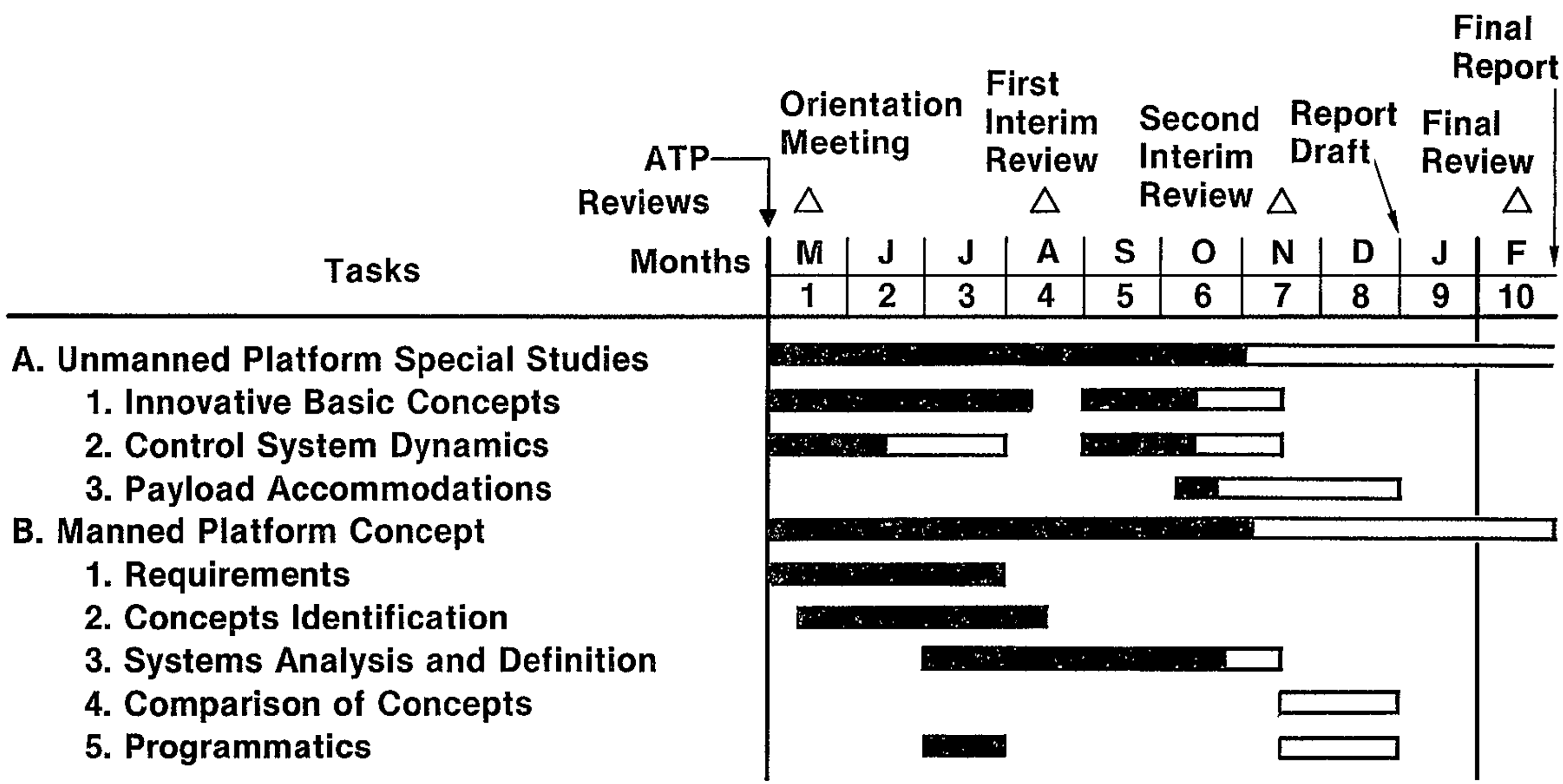
STUDY SCHEDULE



CONTENTS OF BRIEFING

Unmanned Platform

- Image Motion Compensation Interfaces

Manned Platform

- Payloads
  - Early: 90-Day Solar-Terrestrial and Life Science Activities
  - Late: OTV Operations Impacts
- Updated Design Guidelines and Criteria
- Crew Size Sensitivities
- Configuration Design and Accommodations
  - Airlock/Adapter
  - Habitat/Control Center
  - Logistics Module
- Habitability for Each Configuration
- Subsystem Design
  - Approach Options and Sensitivities
  - Division of Functions and Distribution of Equipment
  - Hamilton Standard Inputs on ECLS
- Operations
  - Shuttle Loading
  - Configuration Buildup
- Attitude Durations/Atmospheric Density
- Safety and Reliability
  - Relationship to Power System
  - Redundancy vs Spares
  - Meteoroid Protection
- Programmatics Plans/WBS and Dictionary

TASK A – SCIENCE AND APPLICATIONS SPACE PLATFORM (SASP) (UNMANNED)

VFO797

Special Studies

1. Innovative Basic Concepts: — Tether Data Gathering Only in Report Period

2. Control System Dynamics: (Image Motion Compensation Interfaces) — Data Gathering and Study of "No Pointing System" Case

3. Payload Accommodations Assessment (Started Dynamics/Damping Emphasis)

   – Started 1 November

PLATFORM/PAYLOAD IMAGE MOTION COMPENSATION INTERFACE STUDY (SUBTASK A.2)

VFO803

Objectives

- Gain Insight Into IMC Requirements For Platform Payloads; Particularly When No Auxiliary Pointing System (APS) Is Used
- Increase Overall Understanding of Platform, APS, and Payload Pointing Requirements
- Establish Dialogue Between Platform and Pointing Payload Designers

Approach

- Discuss IMC System Designs and Capabilities With IMC System Designers
- Survey Ground- and Space-Based Pointing and IMC System Designs and Operations
- Generate Potential IMC Requirements For Selected Payloads Assuming No APS Used

Progress

- Contacts With SIRTF and SOT Designers Established
- Survey of SOT and SPIE Pointing Conference (Feb 81) Papers Completed, Summarization Underway

PLATFORM/PAYLOAD IMAGE MOTION COMPENSATION INTERFACE STUDY

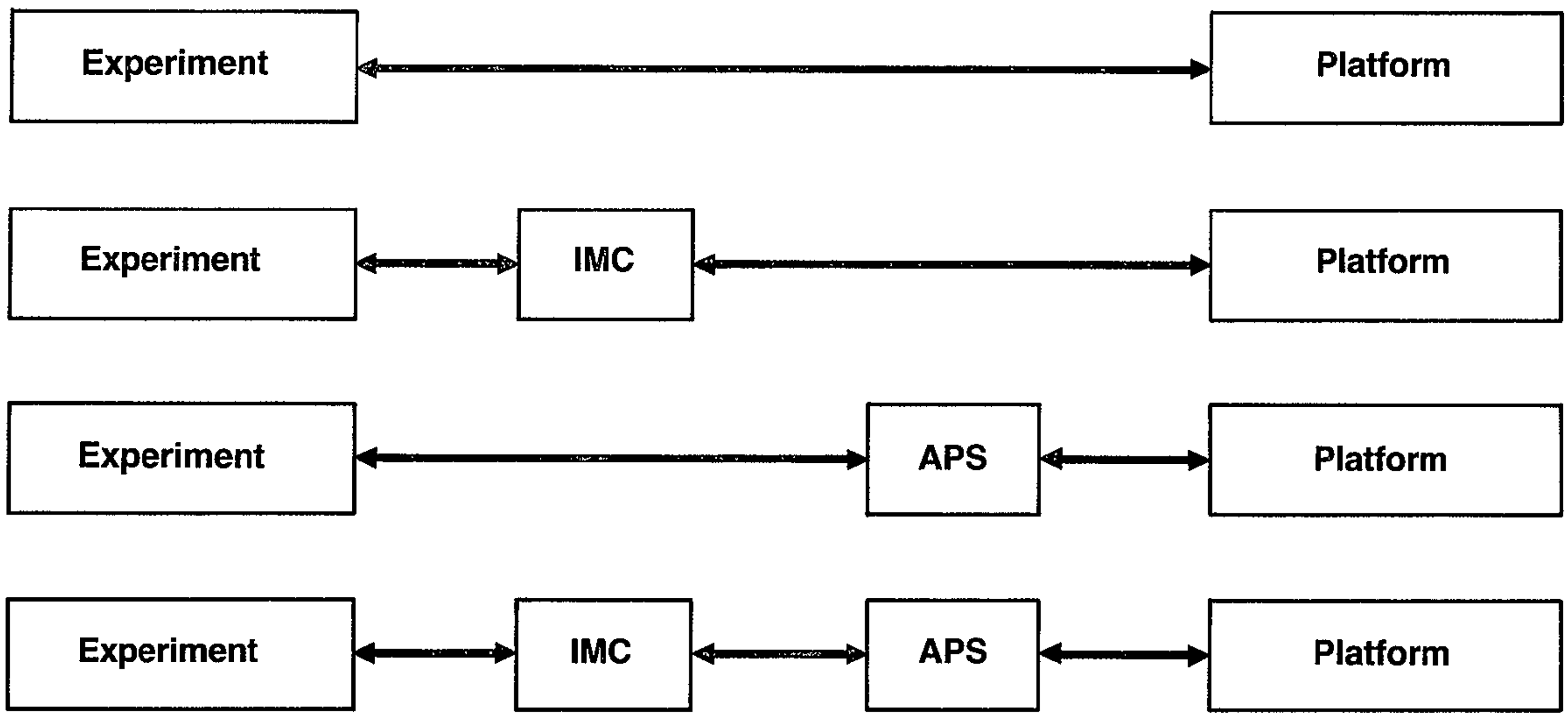
Questions

- What is Appropriate Division of Labor Between Image Motion Compensation (IMC), Auxiliary Pointing Systems (APS), and Space Platform (SP)?

- What Are the Implications/Sensitivities to Increasing the Role of IMC While Reducing the Role of APS?

- Same as Above But Increasing the Role of APS or SP and Reducing the Roles of the Remaining Components

SPACE PLATFORM EXPERIMENT POINTING OPTIONS



IMC = Image Motion Compensation
APS = Auxiliary Pointing System

TYPICAL POINTING COMPONENT FUNCTIONS/ROLES

VFO806

Image Motion Compensation

- Small Amplitude, High Bandwidth Stabilization of Target in Experiment Field of View
- Often Combined With Offset Pointing and Chopping Functions
- Mechanized Within Facility

Auxiliary Pointing System

- Medium-Amplitude, Medium-Bandwidth Stabilization of Facility or Target in Experiment Field of View
- Often Combined with Large Angle Facility Orientation Capabilities
- Mechanized External to the Facility

Space Platform

- Low Bandwidth Stabilization of the Vehicle
- Orientation of Vehicle

REPRESENTATIVE POINTING COMPONENT DATA

VFO807

	Stability (Arc Sec)	Accuracy (Arc Sec)	Amplitude* (Arc Sec)	Bandwidth (Hz)
IMC	<0.01–1	0.1–1	1–10	10–200
APS	0.01–10	0.1–5	60–360	0.1–2
SP	1–120	1–1800	—	0.01–0.5

*Maximum Amplitude For Which Pointing Component Can Compensate

SHUTTLE INFRARED TELESCOPE FACILITY (SIRTF)

Example: SIRTF Operations Operational Modes

Point Source Observation

- Chopping Using Secondary Mirror (5-420 Sec Arc)
- Nodding Whole Facility (Amplitude of Chopping)

Mapping

- Up to 1 x 1-Deg Area
- Raster Motion of Whole Facility

Searching

- Up to 3 x 3-Min Arc Area
- Spirial Search With Secondary Mirror
- Move Whole Facility to Center the Source

Calibration

- Simultaneous Viewing of a Source by Several Sensors

Target Acquisition

- Accurate Slewing to New Target
- Use of Guide Stars and Offset Pointing
- Man Participation Required Some Times
- Scanning/Searching Sometimes Needed

DIRECT SIRTF MOUNTING TO PLATFORM EXAMPLE

VFO787

SHUTTLE-MOUNTED CHARACTERISTICS

Required Performance At Science Instrument

Field Of View	7 Arc Min
Accuracy	1 Arc Sec
Stability	0.25 Arc Sec For 20 Min

Fine Guidance Sensor Field-Of-View

30 Arc Min

IMC Characteristics

Range	5 Arc Sec (APS Gyro Scale Factor Limited)
Frequency Response	10 Hz (Gyro Limited)

Secondary Mirror Driven By APS Gyros

Star Trackers

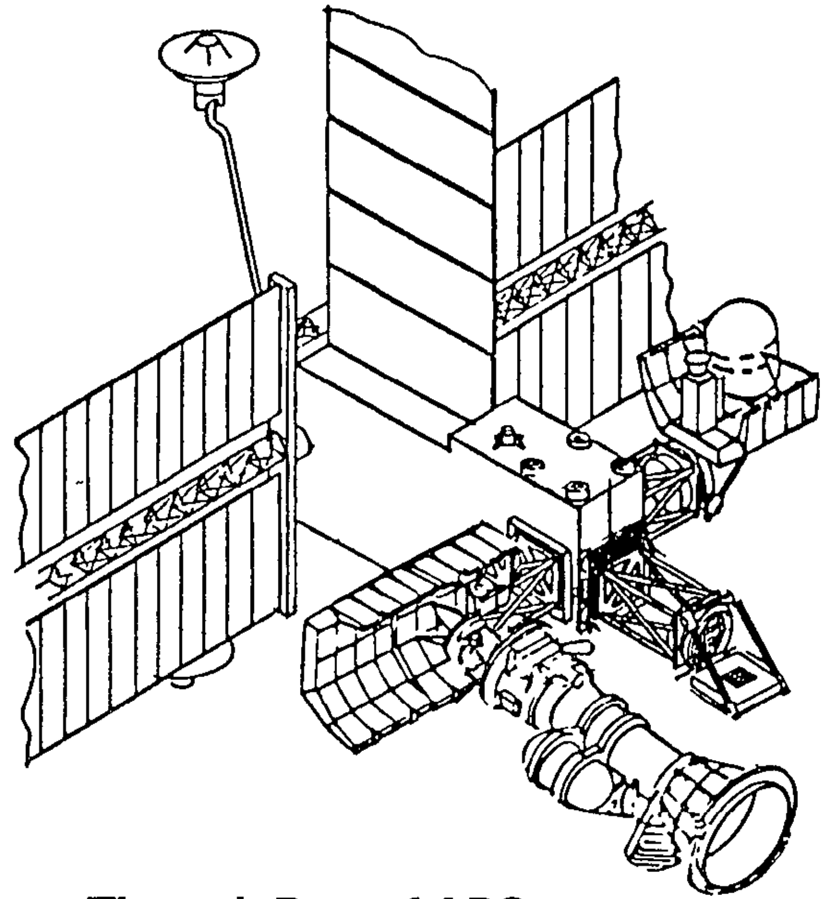
Uses APS Star Trackers

Wide Field Of View (Several Degrees)

DIRECT SIRTF MOUNTING TO PLATFORM EXAMPLE
APS FUNCTIONS TAKEN BY FACILITY OR PLATFORM

VFO786

- Rate Gyros
- Star Trackers*
- Nodding
- Slewing
- Rastering
- Medium Amplitude
  Image Stabilization



***Normally Mounted on Facility Even Though Part of APS**

IMPLICATIONS OF MOUNTING PLAYLOAD DIRECTLY TO PLATFORM

VFO808

- IMC Must Be Designed to Compensate for Platform Stability Characteristics
- Platform Must Provide Accurate Orientation Control and Slewing From Target to Target
- All-Sky Viewing Requires Platform to Have Capability for Holding Large Variety of Orientations
- Increased Operational Conflicts for Multi Pointing-Payloads Operations

DIRECT SIRTF MOUNTING TO PLATFORM

Potential Problem Areas

Replacement of APS Gyros
- SP Gyros Located Relatively Far From Facility So Structure Dynamic Deformations (Thermo and Flexible) Degrade Effectiveness
- May Require Facility-Mounted Gyros

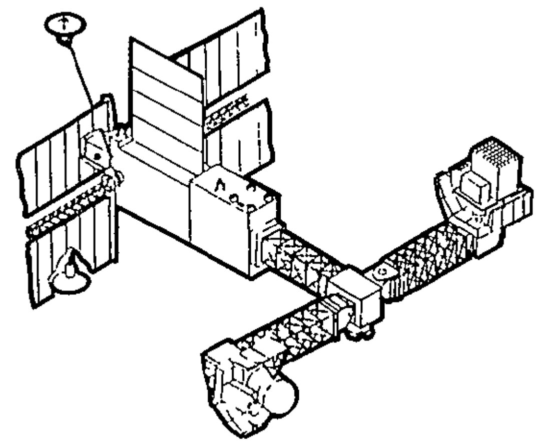
IMC Range Capability
- Gyro-To-Secondary Mirror Servo Feed-Forward Gain Errors May Have To Be Reduced

Operations Requiring Rastering and Nodding
- Whole SP Must Move or Facility Redesigned for More Secondary Mirror Motion Capability (Large Off-Boresight Abberations Must Be Considered Also)

All-Sky Viewing
- SP Has Limited Orientation Capabilities

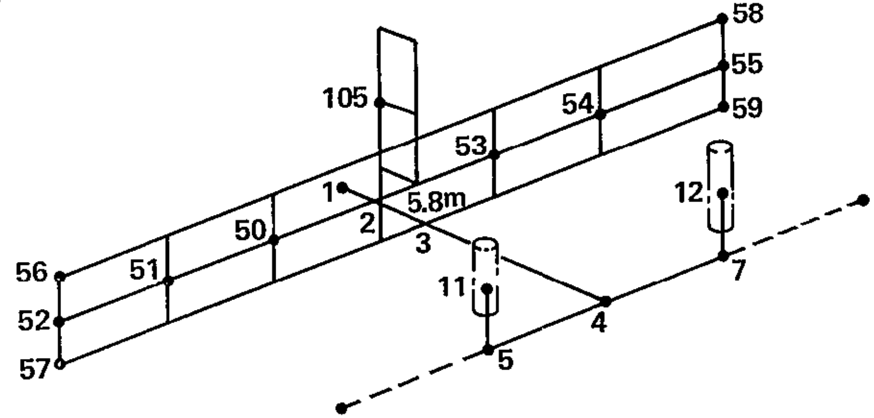
TASK A.3. STRUCTURAL DYNAMICS/ UNMANNED PLATFORM

VFO817



CY 81 Objectives

- Modify Existing Model as Shown
- Calculate Modes, Frequencies (Real and Complex)
- Calculate Phase and Gain versus Frequency
- Estimate Errors From Real Mode Model



TASK A.3. PLATFORM DYNAMIC ANALYSIS GENERAL OBJECTIVES

VFO816

- Assess Disturbance Sensitivity – Payload Motions (Open Loop)
- Provide Controls Reference Model
- Perform Damping Benefit Studies
  - Disturbance Reduction
  - Isolation Effectiveness
  - Controllability Improvements

AGENDA

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■ Programmatics	Denny Niblo

KEY PROGRAM CONSIDERATIONS

- Foundation of Realistic Payloads
- Conservative Budget Assumptions
- Goals for Initial Capability
- Goals for Capability Growth Steps
- Capabilities of Power System
- Extent of Existing Equipment Use
- Revisit/Resupply Logistics Scope
- Safety and Contingency Management
- Involvement and Impacts of Participants Other Than NASA

OBSERVATIONS TO DATE

- Identifiable Payloads Call For Moderate R&D-Type Manned Platform
  (R For Scientific Research)
  (D For Applications, Technology, And Operations Development)
- Growth Capability Can Easily Be Incorporated To Accommodate Demand (When Definitized)
- Spacelab 1- and 2-Segment Modules Adequate For Numerous Elements Of Platform
- Savings Through Use Of Existing Hardware (From Shuttle and Spacelab) Can Be Important In Very Tight Budget
- Crew Size Of 3–4 Adequate For Early Years
- Technology Advancements Required Are Moderate

MANNED PLATFORM PAYLOADS

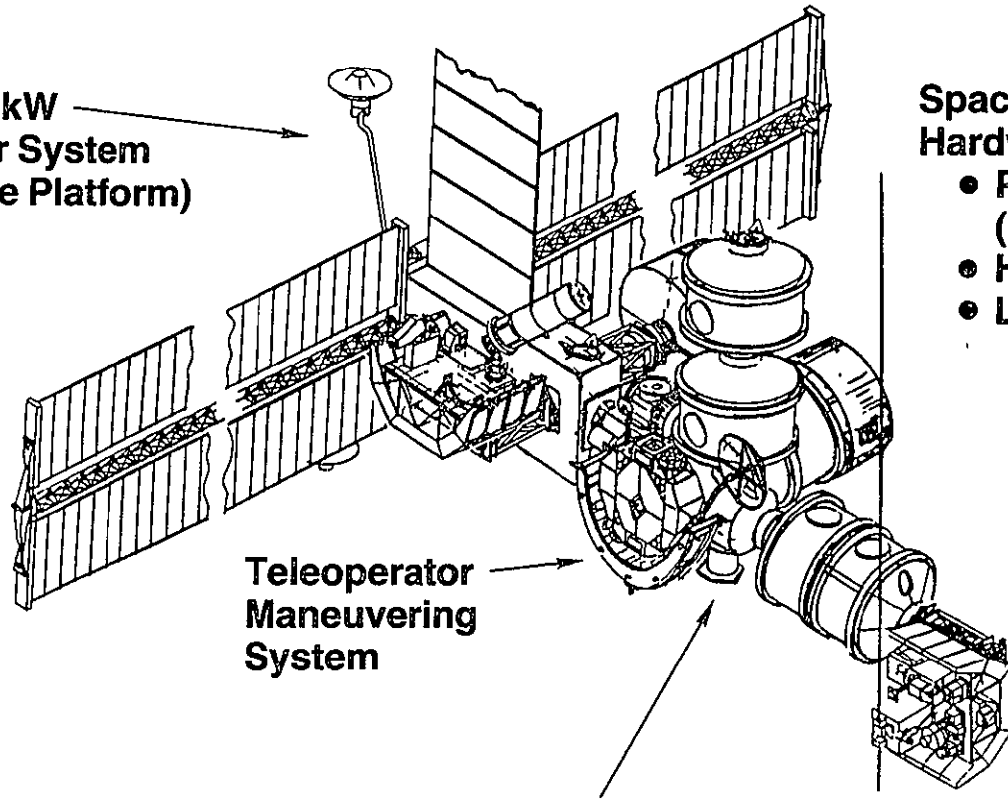
Performance of On-Site Missions	• Solar-Terrestrial Science • Life Science • Manufacturing Applications
Support for Remote Missions	• GEO-Mission Staging • Subsatellites and Targets • Large Payload Setup • Spacecraft Servicing
Support for Advanced Capability Testing	• Support Operations/Equipment • Propellant Storage/Handling • Large Structures • Environmental Controls • Sensors and Pointing Systems • EVA Techniques and Accessories

MANNED PLATFORM PAYLOADS

		Addressed To Date In This Study
Performance of On-Site Missions	• Solar-Terrestrial Science	✓
	• Life Science	✓
	• Manufacturing Applications	✓
Support for Remote Missions	• GEO-Mission Staging	✓
	• Subsatellites and Targets	✓
	• Large Payload Setup	✓
	• Spacecraft Servicing	✓
Support for Advanced Capability Testing	• Support Operations/Equipment	✓
	• Propellant Storage/Handling	✓
	• Large Structures	✓
	• Environmental Controls	✓
	• Sensors and Pointing Systems	✓
	• EVA Techniques and Accessories	✓

VFO800

EARLY MANNED PLATFORM



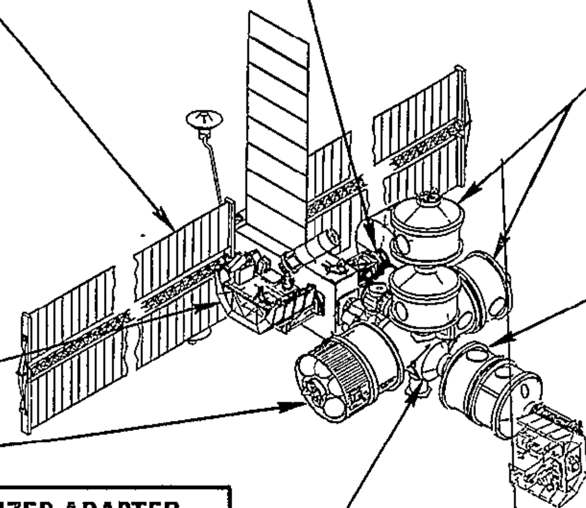
MANNED SPACE PLATFORM

POWER SYSTEM
- ELECTRICAL PWR
- WIDEBAND COMM
- ALTITUDE CONTROL
- HEAT REJECTION
- ORBIT/STATION KEEPING
- BERTHING

POSSIBLE MODS
- VOICE COMM
- EMER PWR

EVA AIRLOCK AND SUBSYSTEMS
- EXISTING FROM ORBITER PROGRAM

INTERIOR PAYLOAD MODULES
- SPACELAB-DERIVED; SINGLE SEGMENTS



EXTERIOR
- PAYLOAD (3 PLCS)

CONTROL CENTER AND HABITAT

DESIGN IMPROVEMENTS
- ADD VOICE INTERCOM
- COMPLEMENT TV SYS
- ADD BERTHING PROVISIONS
- ADD CO_2/CONTAMIN REMOVAL
- IMPROVE SUBSYS LIFETIME
- IMPROVED INSULATION SYS

EXISTING SPACELAB ITEMS
- STRUCTURE SYS
- PWR DIST
- THERMAL CONTROL SYS
- DATA MGT SYS
- CONTROLS AND DISPLAYS
- EXPERIMENT RACKS AND SERVICES
- INSULATION SYS
- ATMOSPHERE REVITALIZATION

CREW EQUIPMENT
- FOOD MGMT
- EXERCISE EQUIP
- SLEEP RESTRAINTS

EXISTING FROM ORBITER/SKYLAB PROGRAMS
- EVA SUITS
- STOWAGE LOCKERS

PRESSURIZED ADAPTER
- NEW ITEM
- PWR DIST AND CONTROL
- PWR SYS STATUS
- ATMOSPHERE REVITALIZATION
- WATER SUPPLY
- COMM AND DATA MGMT
- WASTE MGMT
- EMER FOOD
- CREW SUPPORT ITEMS

LOGISTICS SYSTEM
- SPACELAB-DERIVED
- SINGLE-SEGMENT SPACELAB
- UNPRESS TANK SECTION

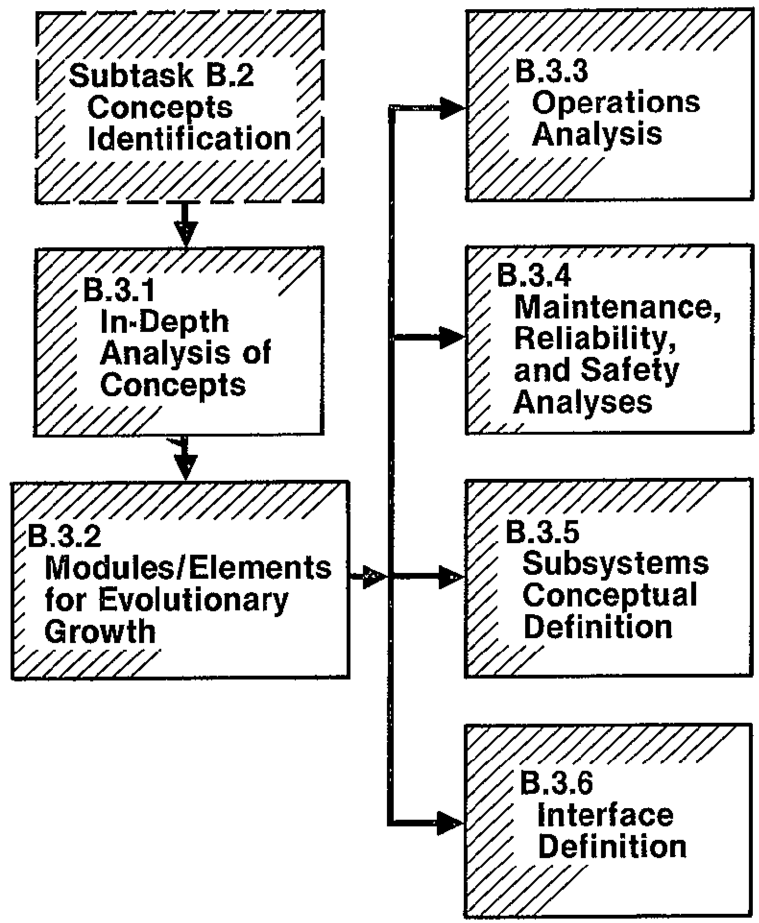
SYSTEMS ANALYSIS AND DEFINITION (SUBTASK B.3)

VFK498N

Inputs

- Power System Design
- Design and Operational Requirements
- Spacelab Hardware Descriptions
- Orbiter Hardware Descriptions
- Star No. 17
- STS User's Handbook
- K-STSM-14.1 Launch Site Accommodation Handbook

Subtask Activity Flow



Outputs

- Engineering Drawings
- System Schematics
- System Specifications
- Weight Statements
- Mass Characteristics
- Dynamic Characteristics
- System Constraints
- Hardware Trees
- System Tradeoffs
- Subsystem Equipment List

VFO801

CONFIGURATION ELEMENT CONCEPTS IDENTIFIED IN FIRST INTERIM BRIEFING

Airlock/Adapter Module

- A Through I Options

Control/Habitat Module

- 2-and 3-Segment Spacelabs

Growth Module

- 1-and 2-Segment Spacelabs

Logistics Module

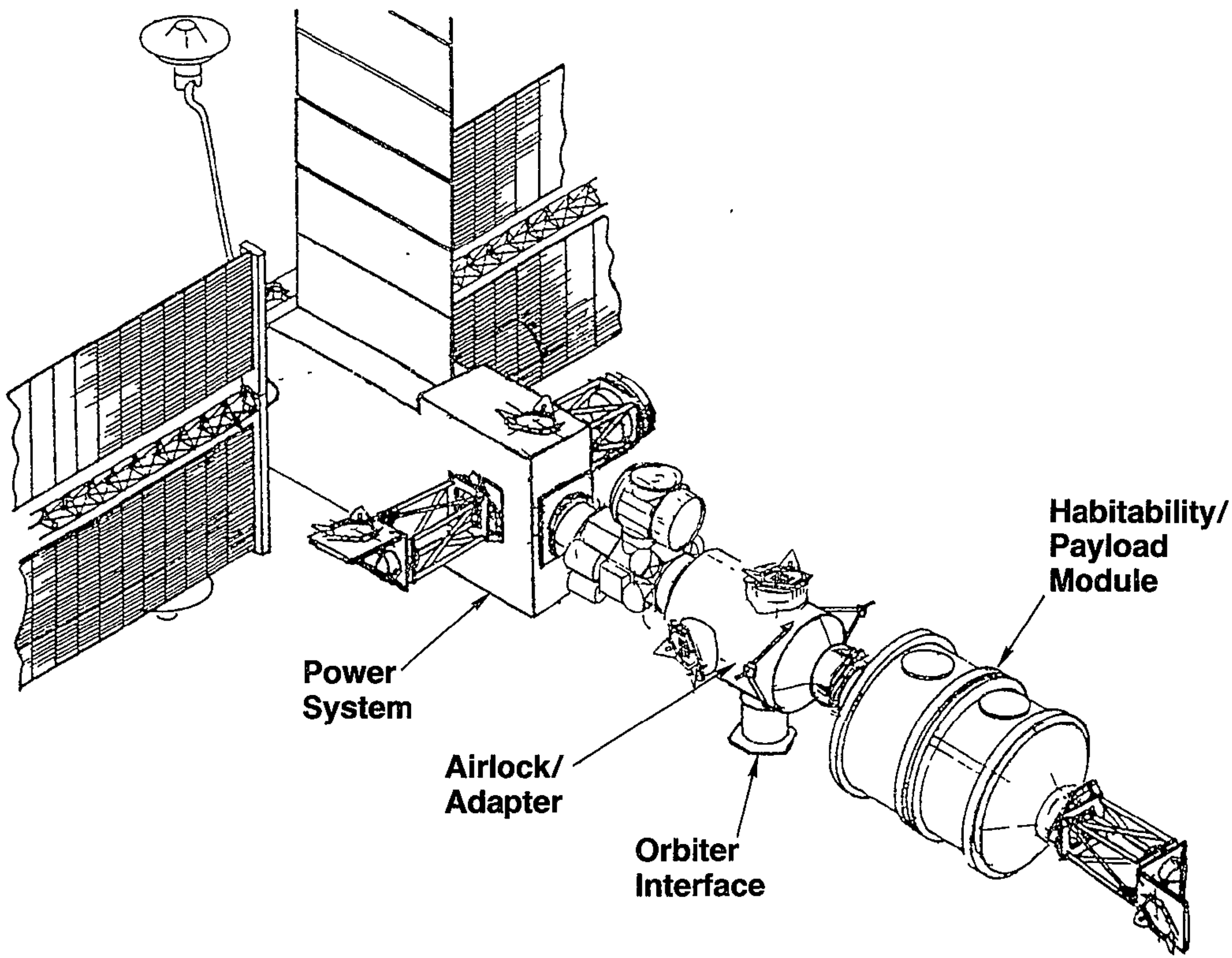
- Unmanned
- Unmanned + Manned
- Unmanned/Manned
- 90 Days
- 180 Days

Payload Operations Arm

- Short
- Long
- Long With Aux RMS

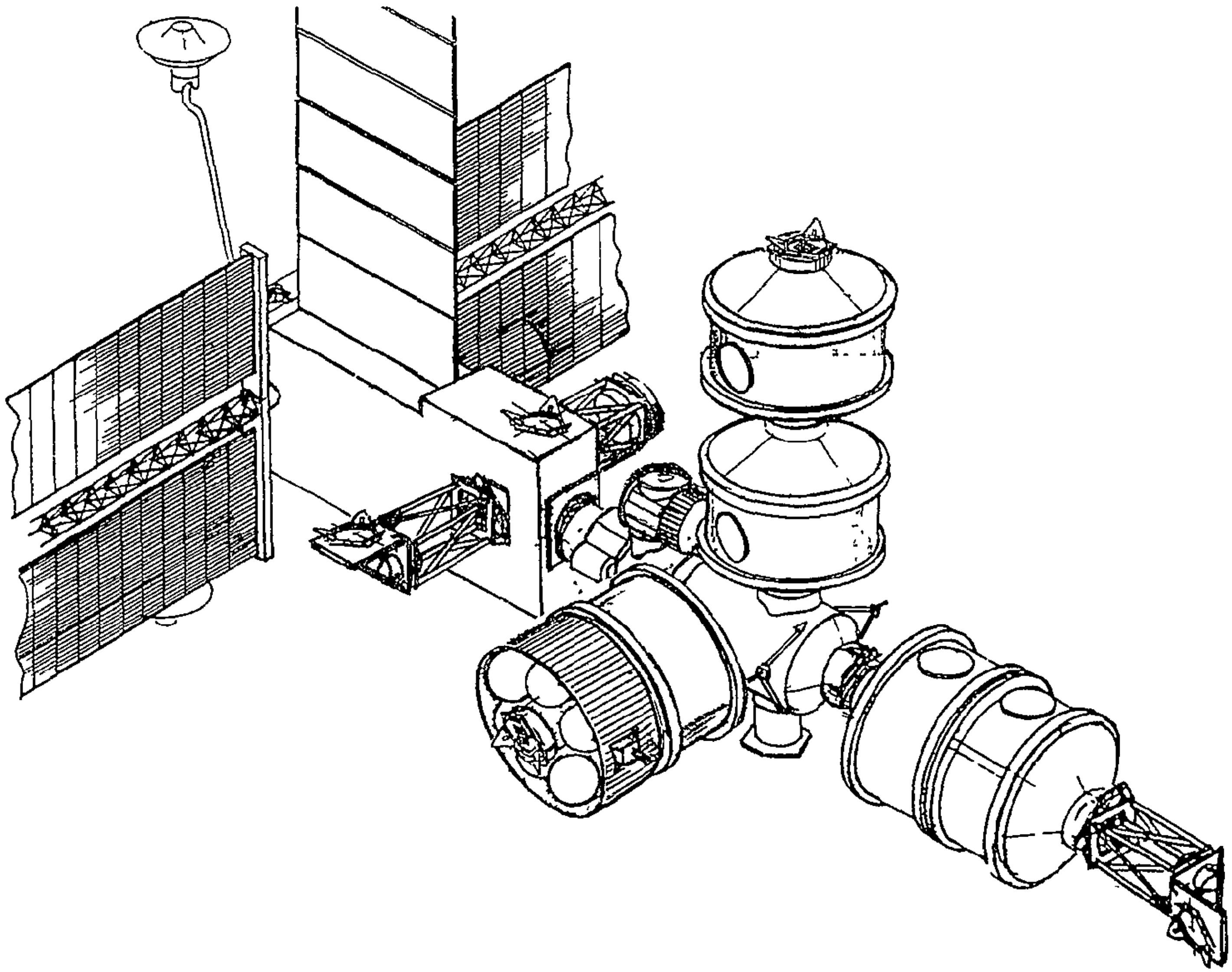
VFO791

BASIC MANNED PLATFORM



VFO792

MANNED PLATFORM



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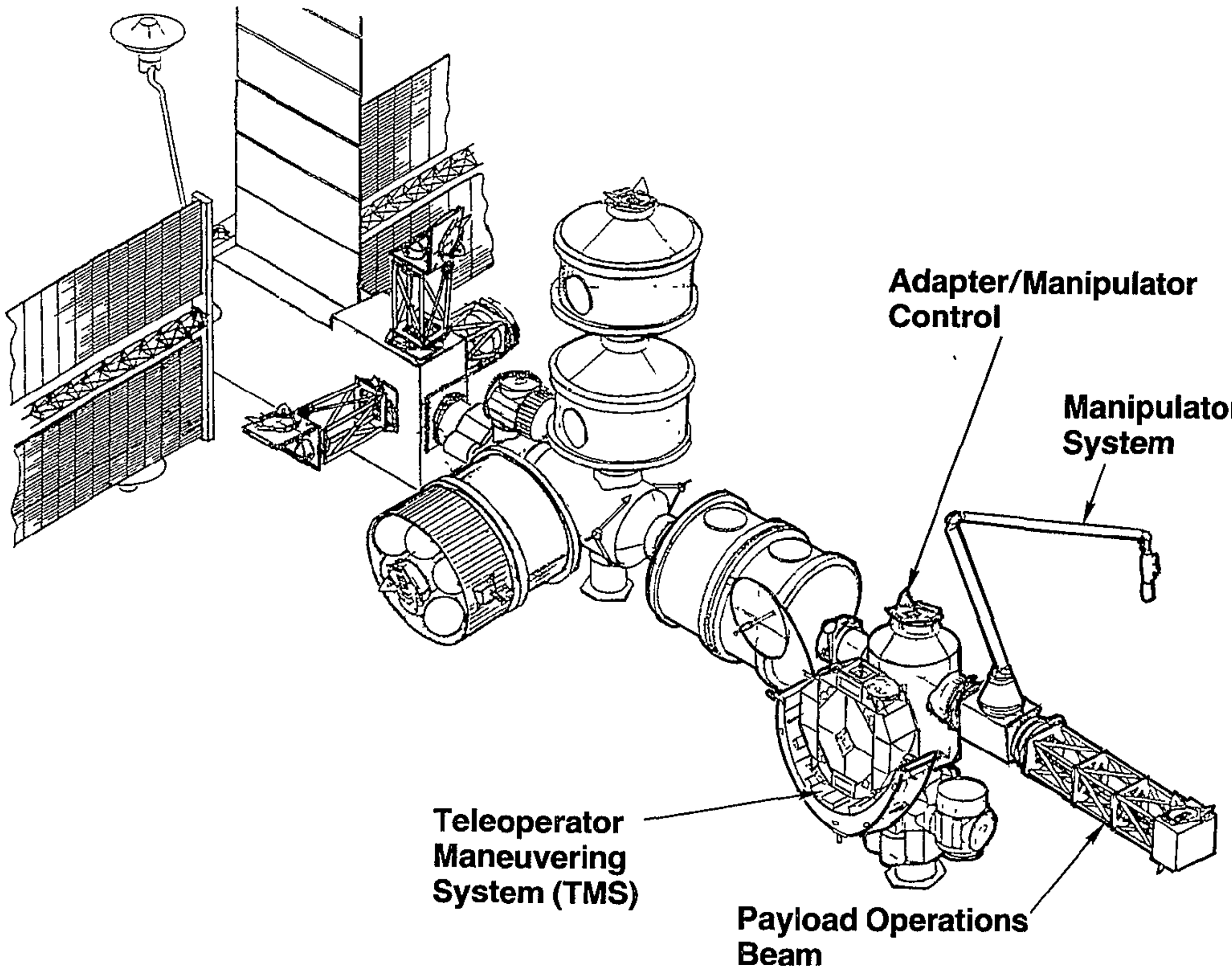
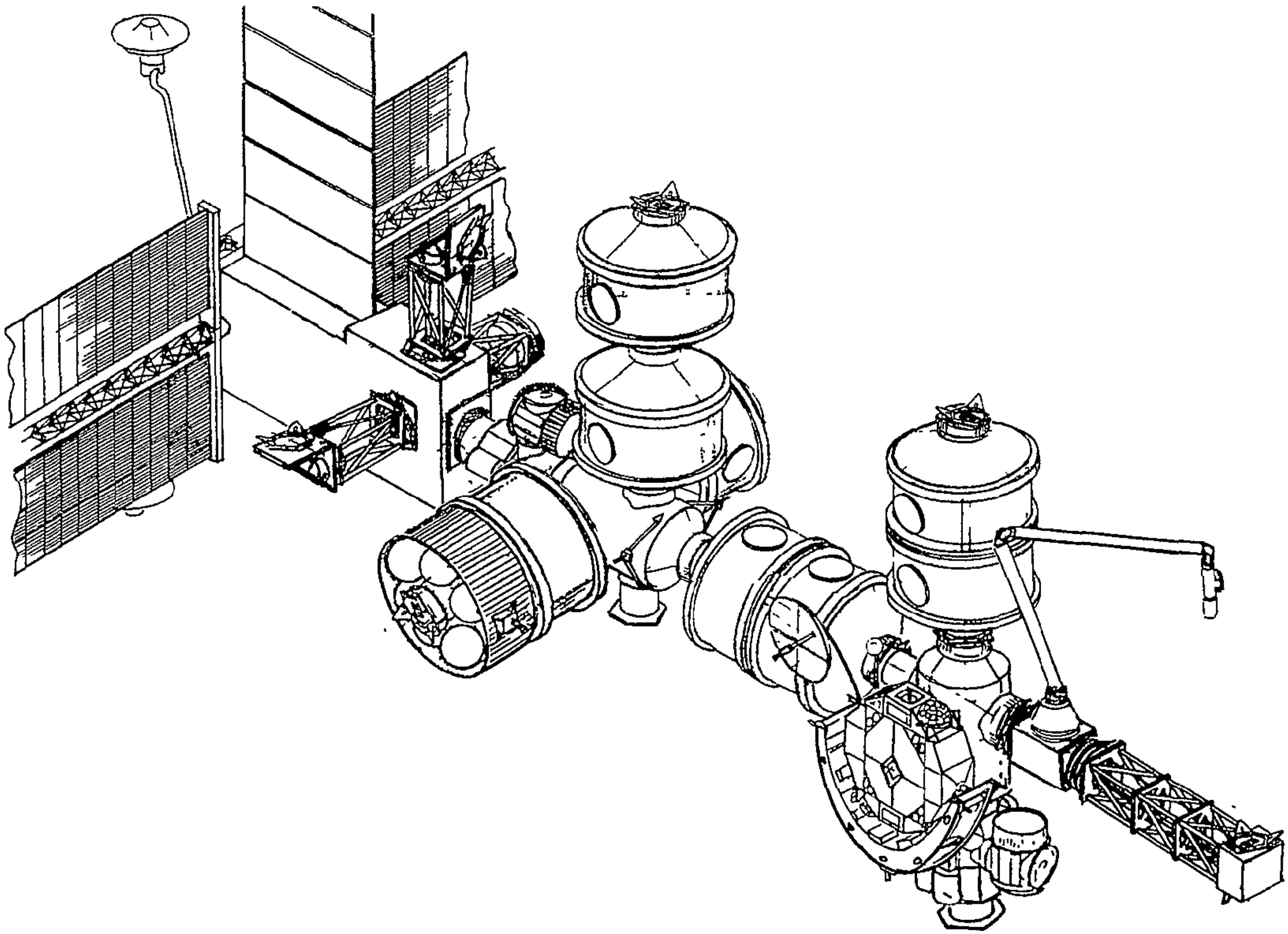
MANNED PLATFORM GROWTH
STEP NO. 1

VFO793



MANNED PLATFORM GROWTH
STEP NO. 2

VFO794



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MSP CONCEPT FORMULATION

Orbiter Physical Interface Parameters Established

- Keel Fittings and Longeron Fittings Availability
- RMS Envelope Restrictions
- Orbiter Cabin Clearances
- Orbiter Berthing Envelope

MSP/Orbiter and Intrasystem Interface Requirements Established and Evaluated

- PS to MSP
- MSP to MSP Elements
- MSP to Orbiter
- PS to Orbiter

Subsystem Functions Allocated to Major Elements of MSP

- PS, Airlock/Adapter, Habitability Module

MSP CONCEPT FORMULATION (CONT)

VFO802

Optional Approaches To Initial Capability

- Primary Unmanned (Manned During Shuttle Visit)
  - Provides Increased Internal Experiment Cability
  - Enables Life Science, Etc., Specimens and Equipment to Be Evaluated On Ground Minimizing On-Orbit Logistics
  - Life-Science-Type Lab Occupies Large Portion of Cargo Bay Wt and Vol On Each Flight-Limits Payload Logistics
  - Enables Design of Maximum Sized Airlock/Adapter For Future Growth Considerations
  - Does Not Require Pressurized Logics System Until Later In Program

- Sustained Manned Residence From Outset
  - After Second Launch – Cargo Wt and Vol Allocated 100% To Payload (Except For Logistics Flights)
  - Internal Experimentation Limited During Early Phase Of Program
  - Design Characteristics Of Airlock/Adapter Module Influenced By Cargo Bay Space Allocation

MSP CONCEPT FORMULATION (CONT)

Nine Candidate Airlock/Adapter Options Investigated

Two Airlock/Adapter Configurations Selected For Further Study.
Concepts Measured Against Identified Requirements and Parameters

- Z-Axis-Oriented Concept
- X-Axis-Oriented Concept

X-Axis A/A Concept Selected For Detail Configuration Analysis

- Maximum External Size and Shape Determined Within Established Orbiter Physical Parameters and Launch Envelope
- Internal Arrangements Investigated to Maximize Use of Available Volume
- "1-g" Orientation Selected With Four Radial Berthing Ports and Two End Ports

MSP CONCEPT FORMULATION (CONT)

VFO756

Two Candidate Habitability/Payload Modules Evaluated

- A 2-Segment Spacelab
- A 3-Segment Spacelab

A 2-Segment Spacelab Was Selected For Detail Configuration Analysis

- Internal Arrangements Investigated to Maximize Use of Available Volume
  - Four Crew Sleep Accommodations Concepts Evaluated
  - 1-g and 0-g Orientations Investigated
  - Internal Volume Allocation Options Investigated
  - Crew Size and Subsystem Volume Requirements Established

  1-g Orientation With Private Quarters For Three Crewmen Was Selected For Continued Subsystem Analysis. This Selection Is Considered Minimum Impact on Current Spacelab Systems and Makes Maximum Use of Current Spacelab Equipment.

Detailed Equipment List Prepared: Habitat, Airlock/Adapter, Logistics Module

Five Logistics Options Evaluated

- All EVA Transfer
- IVA Solids, EVA Gases
- IVA Solids, Press Transfer Gases
- IVA Solids From Middeck, Tank Module on MSP
- Tank Module For Gases, Pressurized Module For Solids

- An Integrated Pressurized Module With External Mounted Gas Tanks Selected For Additional Configuration and Operational Analysis

MSP CONCEPT FORMULATION (CONT)

Three-Man Basic Sustenance Weight and Volume Requirements Established For a 90-Day and a 180-Day Resupply Cycle

Favored Logistics System Is As Follows

- 1-Segment Spacelab Module With
  - Interior Water Resupply Tanks
  - Exterior Atmospheric Resupply Tanks
- System Sized For 180-Day Resupply Cycle
- Crew Rotated At 90-Day Intervals With Crew Equipment Transported in Middeck
- Interior Stowage Volume for Exchange of Total Payload in Habitability Module

MANNED PLATFORM ACTIVITIES/ACCOMMODATIONS

VFO356

Activity	Item	Interior Controls	Interior Payload Mounting	Exterior Port	Exterior Operations Beam	Aux RMS
PERFORMANCE OF MISSIONS ON-SITE	• SOLAR-TERRESTRIAL SCIENCE	√		√	√	
	• LIFE SCIENCE	√	√	√		
	• MANUFACTURING APPLICATIONS	√	√	√		
SUPPORT FOR REMOTE MISSIONS	• GEO-MISSION STAGING	√		√	√	√
	• SUBSATELLITES AND TARGETS	√		√	√	√
	• LARGE PAYLOAD SETUP	√		√	√	√
	• SPACECRAFT SERVICING	√				√
SUPPORT FOR ADVANCED CAPABILITY TESTING	• REMOTE CONTROL OPERATIONS	√		√	√	√
	• PROPELLANT STORAGE/HANDLING	√		√	√	√
	• LARGE STRUCTURES	√			√	√
	• ENVIRONMENTAL CONTROLS	√	√			
	• SENSORS AND POINTING SYSTEMS	√		√	√	
	• EVA TECHNIQUES AND ACCESSORIES	√		√	√	√
STATION OPERATION	• CONTROLS/INSTRUMENTATION/ DATA HDLG	√				
	• CREW AND RELATED EQUIPMENT (IVA/EVA)	√	√			
LOGISTICS	• CREW AND PAYLOAD SUSTENANCE AND EXCHANGE	√		√		√

(Column group heading: ACCOMMODATIONS)

VFO364

ALLOCATION OF SUBSYSTEM FUNCTIONS

POWER SYSTEM

- STRUCTURE/MECHANICAL
  - PAYLOAD INTERFACE STRUCTURE(S)
  - PAYLOAD INTERFACE MECHANISM(S) (ACTIVE) (3 PLACES)
  - ORBITER BERTHING MECHANISM (UNMANNED SORTIE MODE)
- ELECTRICAL POWER SYS (EPS)
  - POWER SOURCE
  - BATTERIES, CHARGERS, AND REGULATION
  - POWER DISTRIBUTION AND CONTROL
- THERMAL CONTROL SYS (TCS)
  - HEAT REJECTION RADIATOR
  - INTERFACE HEAT EXCHANGERS AND DISCONNECTS
  - TEMPERATURE CONTROLS
  - F-21 LOOP

AIRLOCK/ADAPTER

- STRUCTURE/MECHANICAL
  - ORBITER BERTHING/DOCKING INTERFACE (PASSIVE)
  - POWER SYSTEM/BERTHING INTERFACE (PASSIVE)
  - PRESSURIZED VOLUME FOR SECONDARY SHELTER
  - PAYLOAD BERTHING PORTS (ACTIVE)
  - SECONDARY SUPPORT STRUCTURE
  - PRESSURIZED VOLUME FOR EVA (AIRLOCK)
  - EMERGENCY VENT SYSTEM
  - RESTRAINTS AND LOCOMOTIVE AIDS
- ELECTRICAL POWER SYSTEM
  - POWER SYSTEM STATUS AND MONITORING
  - POWER DISTRIBUTION AND CONTROL
  - INVERTERS*
  - LIGHTING
  - EMERGENCY POWER DISTRIBUTER
- THERMAL/ENVIRONMENTAL CONTROL & LIFE SUPPORT SYS
  - REPRESSURIZATION TANKS
  - ATMOSPHERE REVITALIZATION
  - ATMOSPHERE CONTROL
  - AVIONICS COOLING LOOP
  - WATER LOOP AND PUMP PKGS
  - EVA SUPPORT

HABITABILITY/PAYLOAD MODULE

- STRUCTURE/MECHANICAL
  - INTERFACE MECHANISM – 1 ACTIVE AND 1 PASSIVE
  - PRIMARY PRESSURE SHELL
  - METEROID SHIELDING AND THERMAL BLANKET
  - INTERNAL SECONDARY SUPPORTS
    - RACKS & OVERHEAD STRUCTURE
    - FLOOR
  - OPTIC WINDOW & VIEW-PORT(S)
- ELECTRICAL POWER SYSTEM
  - POWER DISTRIBUTION AND
  - CONTROL
  - EMERGENCY POWER DISTRIBUTION (BATTERIES)*
  - LIGHTING
  - INVERTERS
- THERMAL ENVIRONMENTAL CONTROL & LIFE SUPPORT SYS
  - ATMOSPHERE CONTROL
  - ATMOSPHERE REVITALIZATION
  - AVIONICS COOLING LOOP
  - WATER DISTRIBUTION
  - WATER LOOP

ALLOCATION OF SUBSYSTEM FUNCTIONS (CONT)

VFO365

POWER SYSTEM

- COMM & DATA MGMT SYS
  - GROUND COMMUNICATION
  - ORBITER COMMUNICATION
  - DETACHED MODULE/EVA COMM
  - PS DATA ACQUISITION
  - PS COMMAND PROCESSING
  - PS PAYLOAD SUPPORT
- REBOOST/DEBOOST SYS
- ATTITUDE CONTROL SYS (ACS)
  - CMG INSTL
  - HORIZON & SUN SENSORS
  - RATE GYROS, ETC
  - MAGNETIC TORQUERS

AIRLOCK/ADAPTER

- COMM & DATA MGMT SYS
  - ENGINEERING DATA ACQUISITION
  - DATA PROCESSING
  - DATA STORAGE
  - DATA MULTIPLEXING
  - DATA DISPLAY/KEYBOARD
  - C&W PANEL
  - TV CAMERA/MONITOR
  - VOICE INTERCOMM
- HABITABILITY
  - WASTE MANAGEMENT
  - FOOD FREEZERS
  - TOOLS
  - RESTRAINTS AND LOCOMOTION AIDS
  - EVA SUITS STORAGE AND REPAIR EQUIP
  - EMERGENCY FOOD STORAGE

HABITABILITY/PAYLOAD MODULE

- COMM & DATA MGMT SYS
  - ENGINEERING DATA ACQUISITION
  - BACKUP DATA PROCESSING
  - DATA DISPLAY/KEYBOARD
  - C&W PANEL
  - TV CAMERA/MONITOR
  - VOICE INTERCOMM
  - SCIENCE DATA ACQUISITION
- HABITABILITY
  - FOOD FREEZER AND REFRIGERATOR
  - EXERCISE AND RECREATION
  - HYGIENE
  - MEDICAL TREATMENT
  - CREW QUARTERS
  - RESTRAINTS AND LOCOMOTION AIDS
  - TOOLS
  - FOOD PREPARATION AND EATING
  - EMERGENCY WASTE
  - PERSONAL RESCUE SYSTEM

VF0578

BASIC MANNED PLATFORM ASSEMBLY ITEMS

Assembly	No. and Location		
	Log.	A/A	Hab
★ Structure Systems			
Primary Structure			
• Fwd End Dome		✓	✓
• Cylinder Section		✓	2
• Aft End Dome		✓	✓
• Tunnel		✓	
• Tunnel Closure		1	
• Trunnion Fitting	2	2	2
• Keel Fitting	1	1	1
• Hard Points	✓	✓	✓
• External Insulation	✓	✓	✓
Secondary Structure			
• Floor		✓	✓
• Floor Support		✓	✓
• Sub Floor		✓	✓
• Floor End Closure		2	2
• Racks	✓	✓	✓
• Tunnel Rack		✓	

Assembly	No. and Location		
	Log.	A/A	Hab
Secondary Structure (Cont)			
• Overhead Structure			✓
• Support Structure			
— Racks	✓	✓	✓
— Tunnel Rack		✓	
— Tanks		✓	
• Airlock		✓	
• Handrails	✓	✓	✓
★ Mechanical Systems			
Hatches	2	8	2
Berthing Mech			
• Passive	1	2	1
• Active	1	4	1
• Umbilical			
— Passive	1	2	1
— Active	1	4	1

BASIC MANNED PLATFORM ASSEMBLY ITEMS (CONT)

VFO581

Assembly	No. and Location		
	Log.	A/A	Hab
★ Crew Accommodations			
Restraints			
• Sleep			3
• Zero-g (Work Sta)		✓	✓
• EVA			
— Tethers	✓	✓	✓
— Handrails	✓	✓	✓
Storage Containers			
• Rack (Spacelab-Type)		✓	✓
• Overhead Type			✓
• Food	✓	✓	✓
• Clothing	✓		✓
Misc	✓	✓	✓
Hygiene System			
• Urine Tank		✓	
• Fecal Tank		✓	
• Waste Mgmt Equip		✓	
• Consumables	✓	✓	
• Sink/Dryer			✓

Assembly	No. and Location		
	Log.	A/A	Hab
Food Management System			
• Freezer			✓
• Refrigerator			✓
• Water Heater			✓
• Food	✓	✓	✓
• Food Stowage	✓	✓	✓
• Utensils			✓
Trash Management System			
• Compactor			✓
• Canister	✓		✓
• Bags & Liner	✓		✓
• Supports	✓		✓
Water Management System			
• Water Separation			
• Water Recovery			
• Water Dispenser			✓
• Portable Water Supply Tanks	✓	✓	
• Initial H_2O Supply		✓	

BASIC MANNED PLATFORM ASSEMBLY ITEMS (CONT)

VF0579

Assembly	No. and Location		
	Log.	A/A	Hab
★ Interior Furnishings			
Partitions			
• Crew Quarters			3
• Waste Mgmt		✓	
Doors			
• Crew Quarters			3
• Waste Mgmt		1	
Consoles		✓	✓
Equipment			
• Table			3
• Desk			1
• Misc		✓	✓
Lighting — Interior	✓	✓	✓
Lighting — Exterior:			
• Berthing		✓	
• Orientatin		✓	
• Acquisition		✓	
• EVA	✓	✓	✓
• Assembly		✓	✓
Personal Gear			
• Hygiene Items			✓
• Garmets	✓		✓
• Bedding			✓
• Misc			
— Portable Life Support		✓	✓

Assembly	No. and Location		
	Log.	A/A	Hab
Personal Gear (Cont)			
• O_2 Mask	✓	✓	✓
• IVA/EVA Life Support		✓	✓
• Pressure Suit			3
• Portable Lights	✓	✓	✓
• Portable Fire Ext.	✓	✓	✓
Crew Support			
• Medical Supplies			✓
• Recreation Equip.			✓
• Exercise Equip.			✓
• Flight Ops Gear			✓
★ Electrical Power			
Power Distribution			
• 30-VDC Dist		1	1
• AC Power Dist		1	1
• Emer Pwr Dist		1	1
• Inverter		2	2
• 120-VDC Pwr Dist		1	
Power Conditining		1	1
Power Reg & Control		1	1
Batteries & Chargers		✓	✓
Wiring	✓	✓	✓

BASIC MANNED PLATFORM ASSEMBLY ITEMS (CONT)

VFO582

Assembly	No. and Location		
	Log.	A/A	Hab
★ Active Thermal Control			
Water Pump Package	0	1	1
Cold Plates	0		
Lines & Disconnects		Set	Set
★ Atmospheric Storage and Control			
N_2 Tanks	12	7	
N_2 Fill and Relief	✓	✓	
O_2 Tanks	18	9	
O_2 Fill and Relief	✓	✓	
O_2/N_2 Control Panel	✓	✓	
Vent and Relief Valves	✓	✓	✓
Sensor Panel	✓	✓	✓
Lines and Disconnects	✓	✓	✓
Airlock Pressure Control		✓	
★ Atmospheric Revitalization			
Cabin Fan Assembly	1	1	1
Condensing HX	1	1	1
CO_2 Control			
Air Temperature Control	1	1	1
Condensate Separator	1	1	1
Condensate Processor			
Condensate Storage and Dump			

Assembly	No. and Location		
	Log.	A/A	Hab
Avionics Fan Assembly	1	1	1
Avionics HX	1	1	1
Rack Cooling Hardware		✓	✓
Fire Detection & Suppression		✓	✓
Ducting			
★ Water Management			
Water Tanks	19	19	0
Water Distribution			
Water Heater/Chiller			1
Water Monitoring			
Waste Water Dump Assy			
★ Waste Management			
Metabolic Waste Collector		1	
Metabolic Waste Processor		1	
Compactor			
Emer. Waste Collection			1
★ Food Management			
Food Freezer	1		
Food Refrigerator			1
Food Preparatin Assembly			1

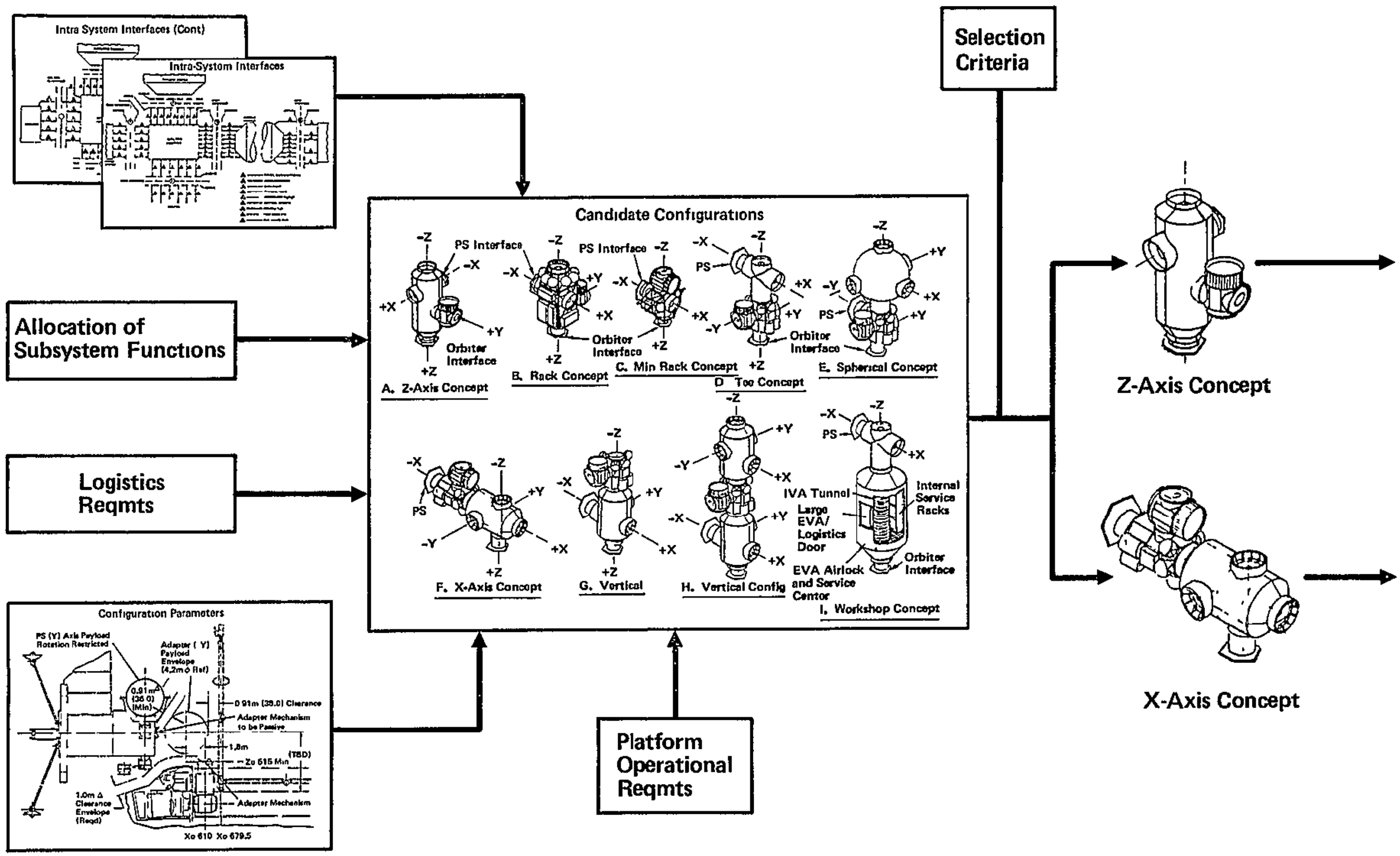
BASIC MANNED PLATFORM ASSEMBLY ITEMS (CONT)

VFO580

Assembly	No. and Location		
	Log.	A/A	Hab
★ Data Management System			
I/O Unit		1	1
S/S RAU	1	2	2
Computer		2	2
DDU/KB		1	1
MMU		1	1
Printer			1
Experiment RAU			2
Engrg Data Recorder			
Wiring			
Displays & Controls — MSP Systems		✓	✓
Displays & Controls — Payload Systems			✓
★ Voice Comm Subsystem			
Intercom Remote Sta		3	3
Loud Speakers		1	1
EVA Comm Set		1	
Audio Signal Processor		1	
Audio Tape Recorder		1	
Intercom Master Sta			1
Wiring			

Assembly	No. and Location		
	Log.	A/A	Hab
★ TV Subsystem			
Video Switching Unit		1	
Video Processor		1	
Video Data Storage		1	
Video Monitor			1
TV Camera — Interior		1	2
TV Camera — Exterior		1	
Camera Control Panel			1
Wiring			
★ Timing Distribution System			
Timing Dist Unit		1	
Timing Display Unit		1	1
Wiring			
★ Caution & Warning Safing System			
C&W Dist Assy		1	
C&W Annunciator		1	1
C&W Processor			1
Sensors & Controls	✓	✓	✓
Wiring			

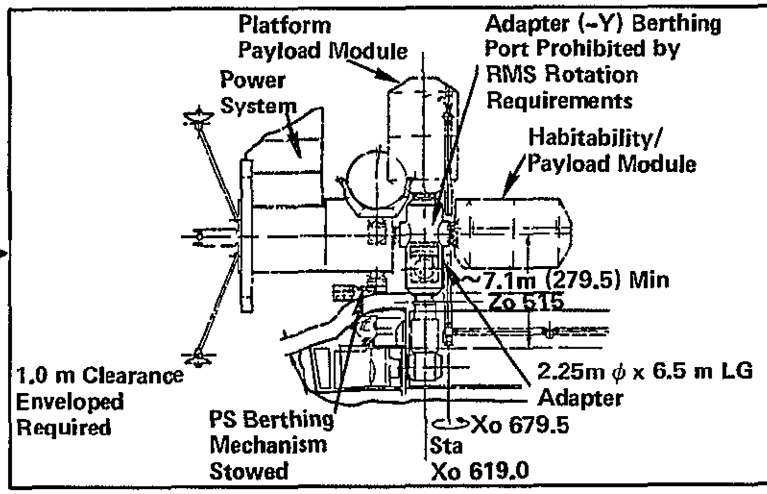
AIRLOCK/ADAPTER CONCEPT FORMULATION



AIRLOCK/ADAPTER CONCEPT FORMULATION (CONT)

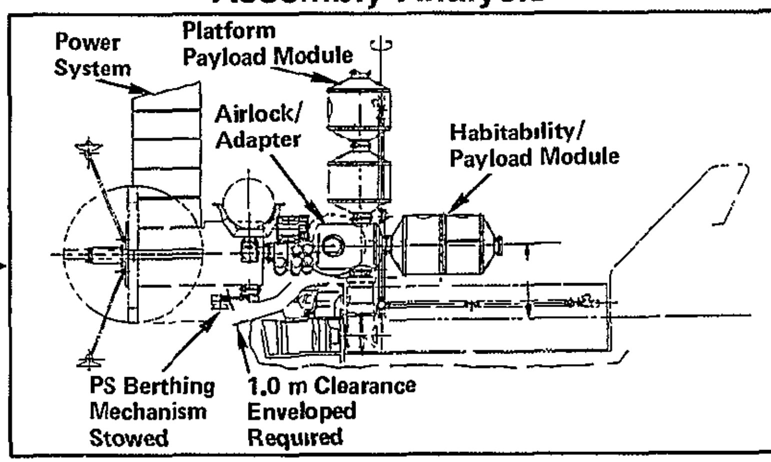
VF0362

Orbiter Launch Parameters

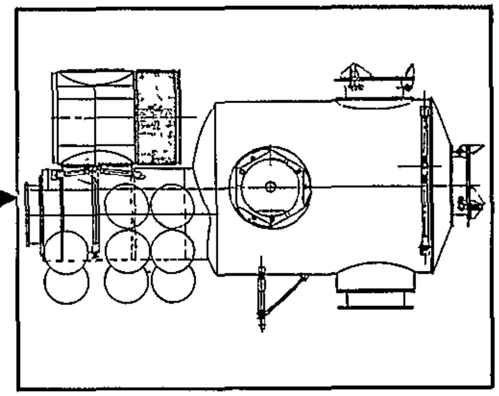


Z-Axis Concept
Assembly Analysis

Orbiter Launch Parameters



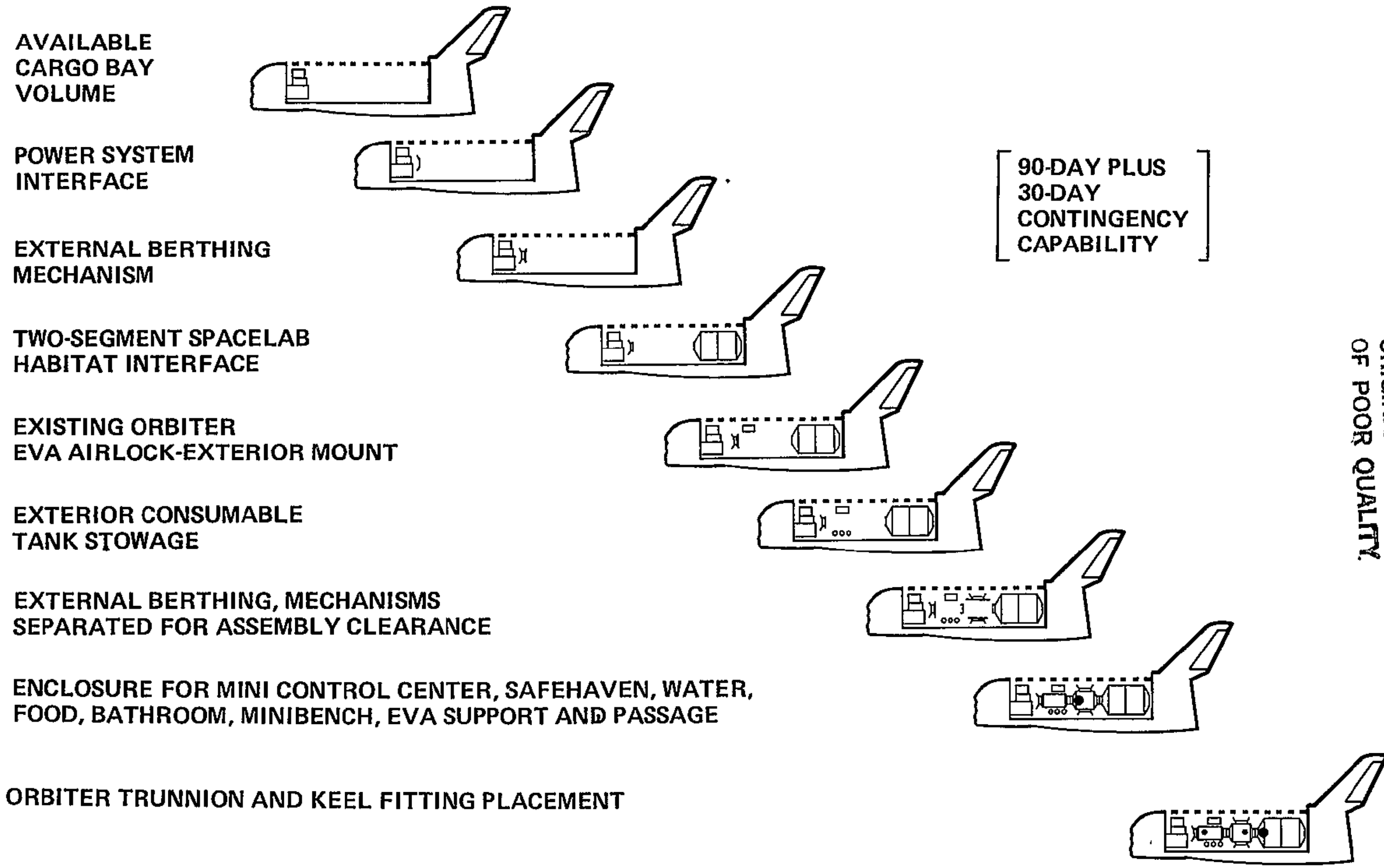
X-Axis Concept
Assembly Analysis



Favored Concept

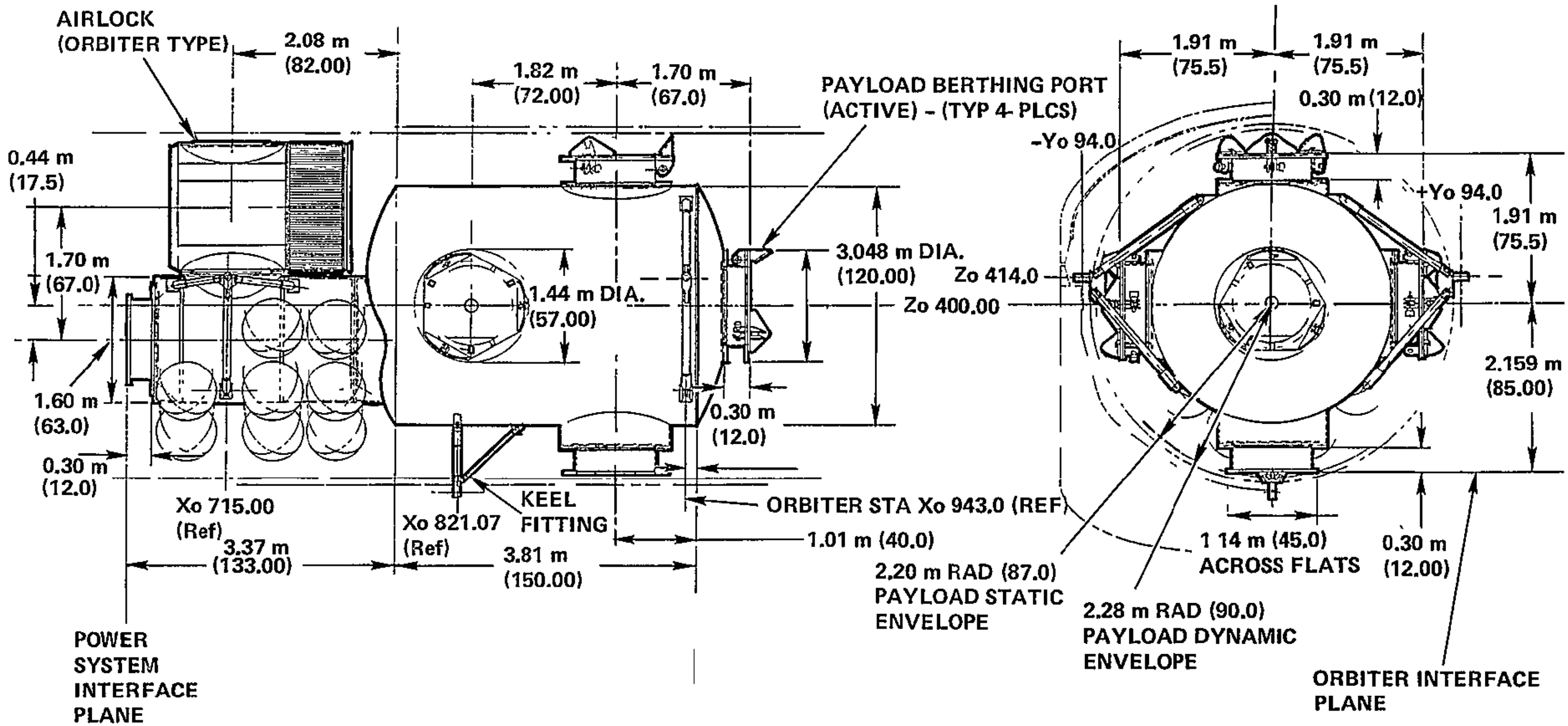
CONFIGURATION DEVELOPMENT SEQUENCE AIRLOCK/ADAPTER MODULE

VF0355



AIRLOCK/ADAPTER OUTBOARD PROFILE

VFO353



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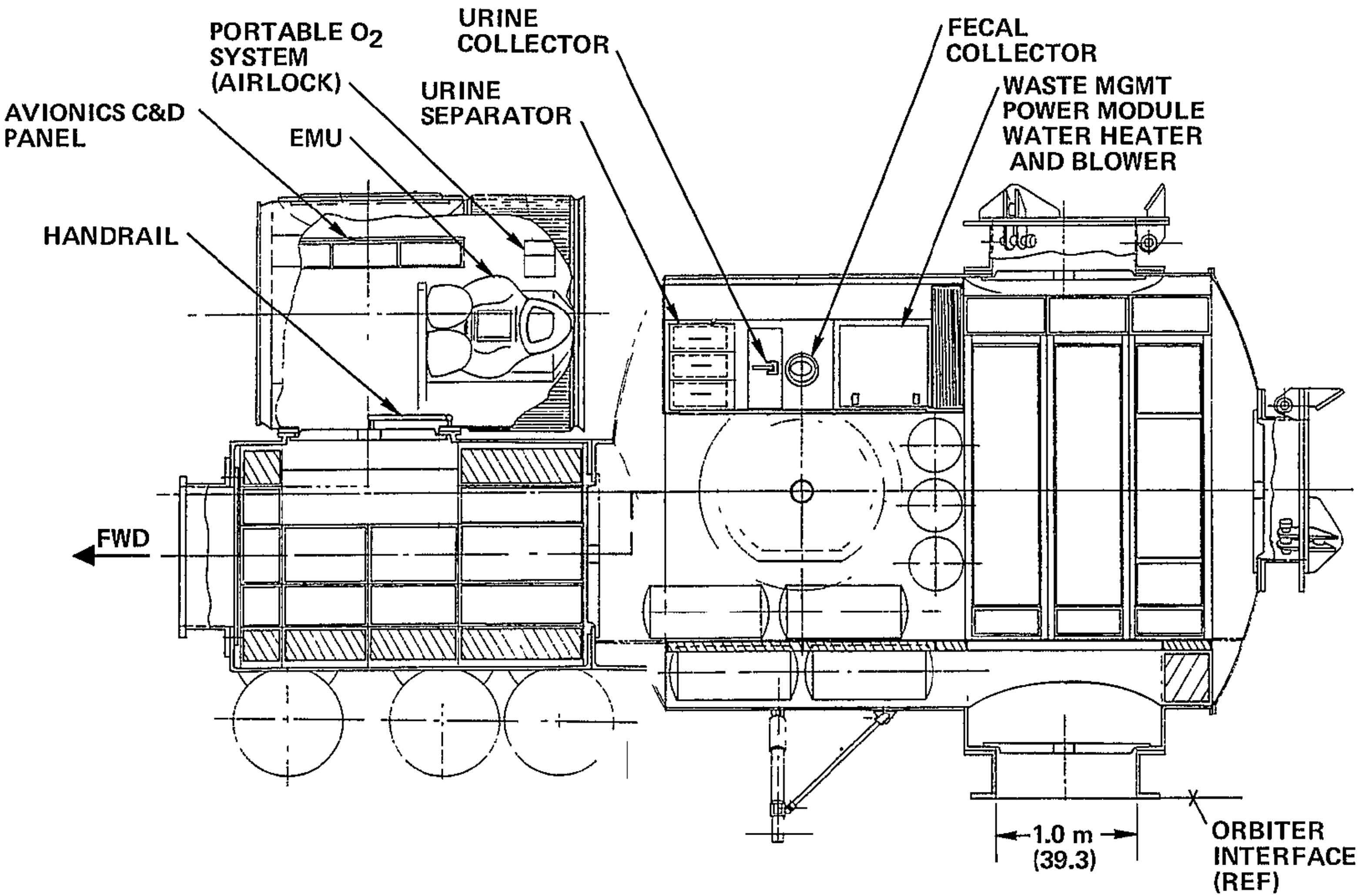
VFO488

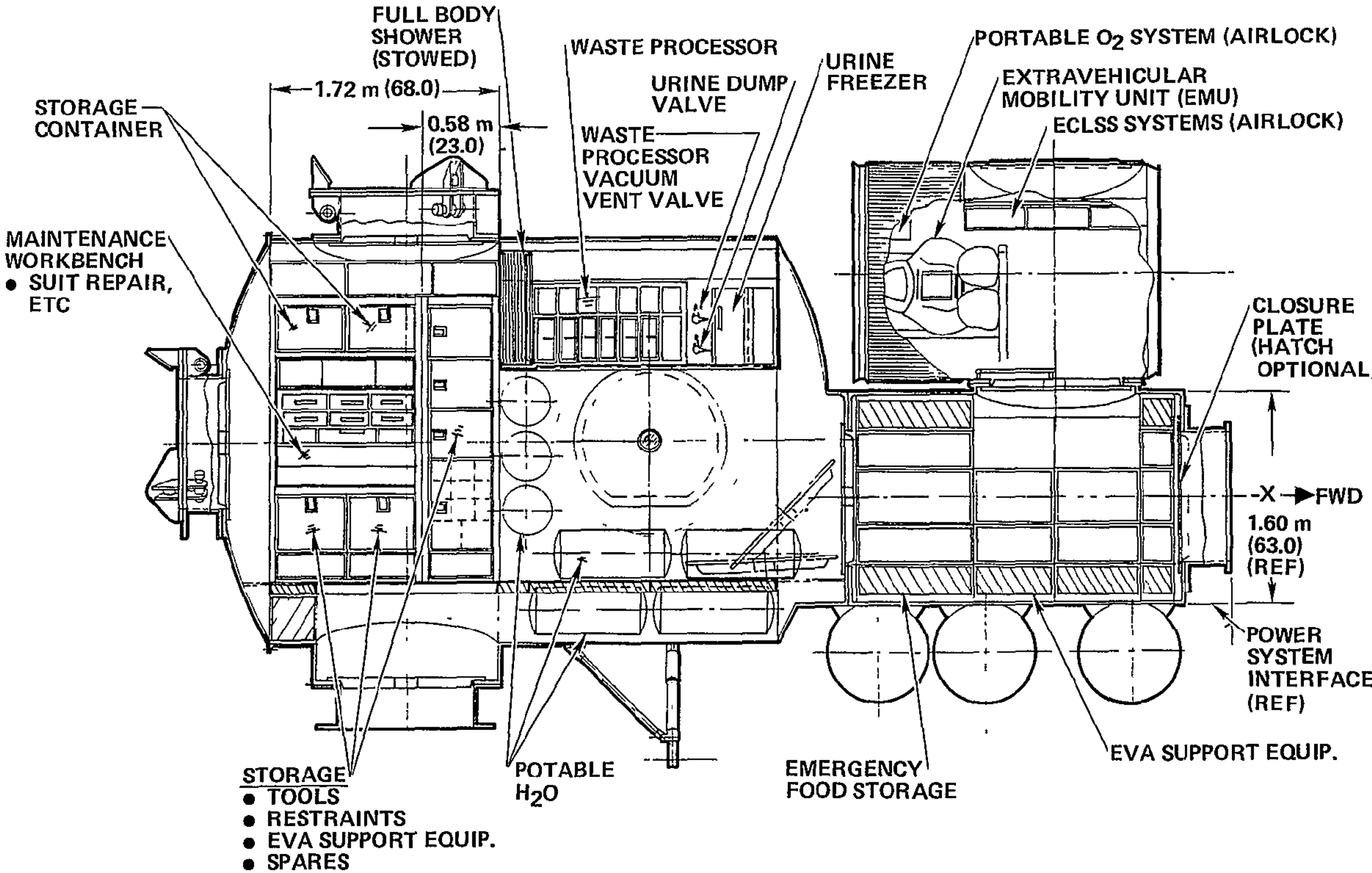
AIRLOCK/ADAPTER INBOARD PROFILE
(STARBOARD SIDE)



AIRLOCK/ADAPTER INBOARD PROFILE

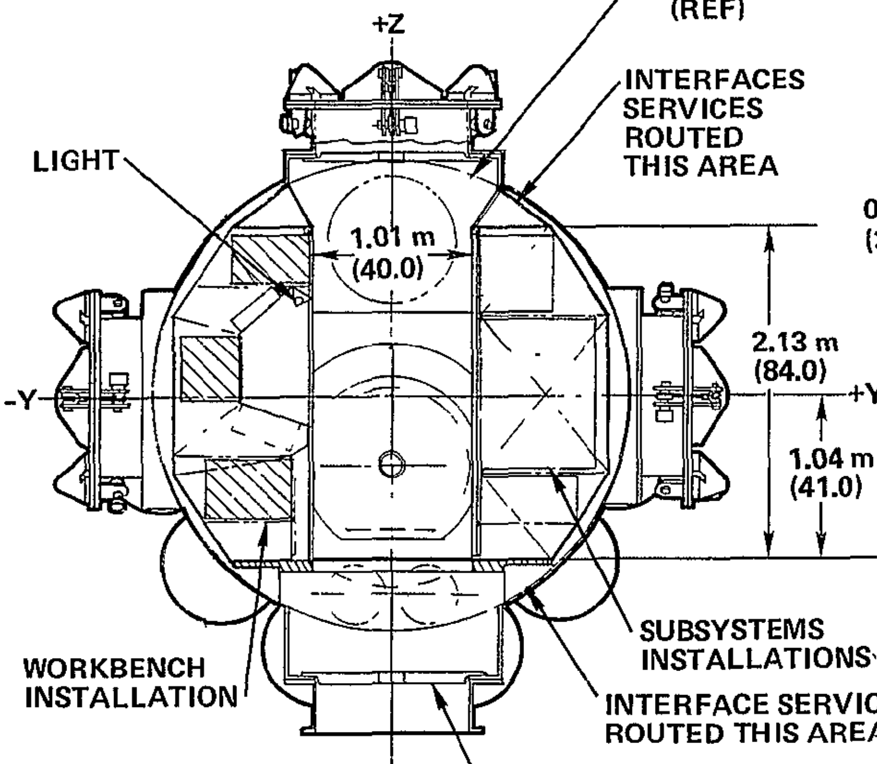
VF0487

(PORT SIDE)

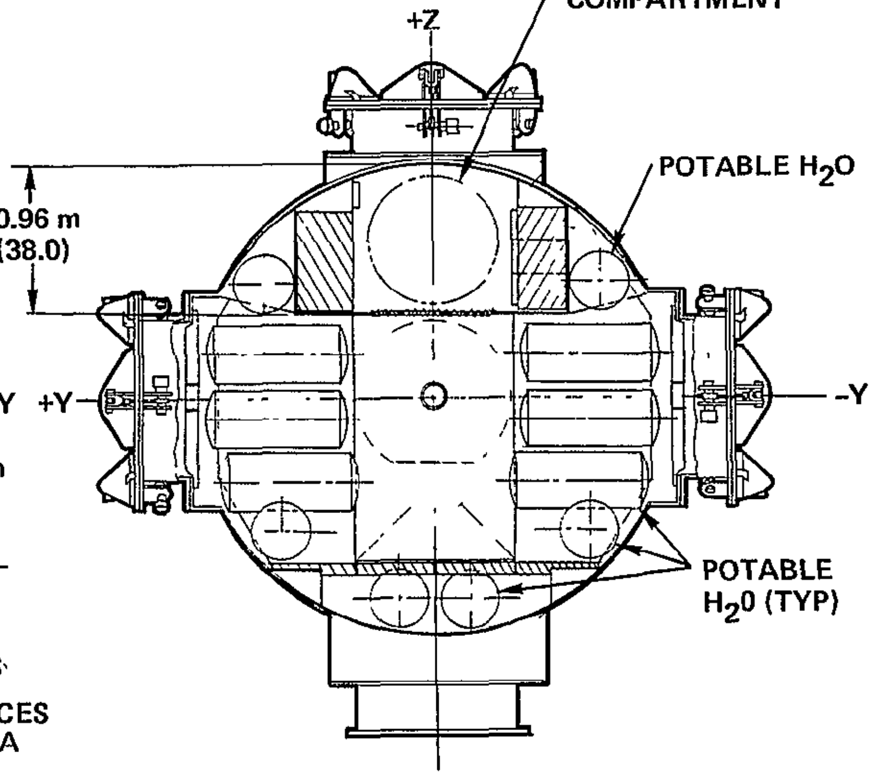


VFO486

AIRLOCK/ADAPTER INBOARD PROFILE



VIEW LOOKING FORWARD



VIEW LOOKING AFT

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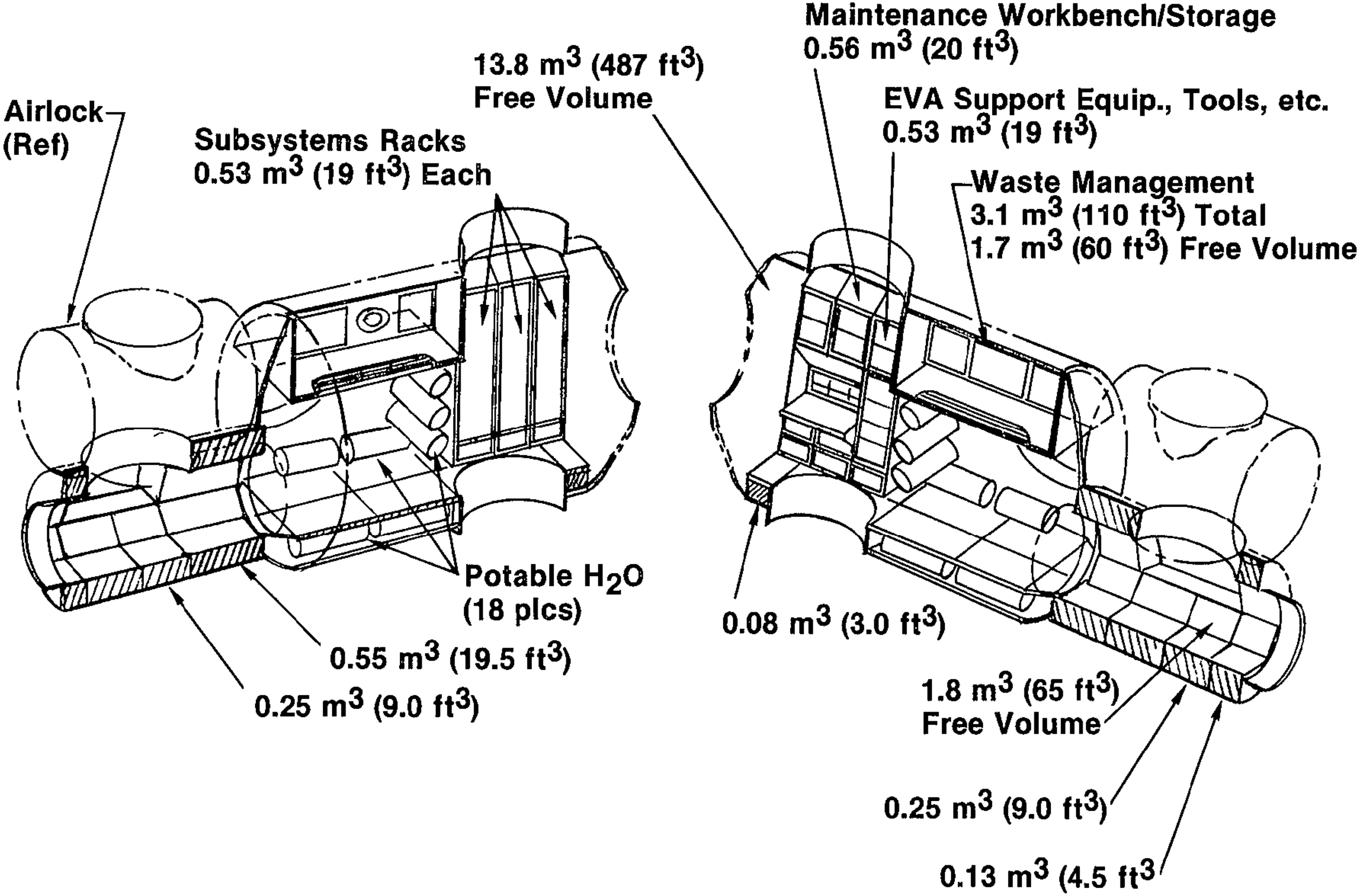
AIRLOCK ADAPTER MODULE VOLUME ALLOCATION

VFO407



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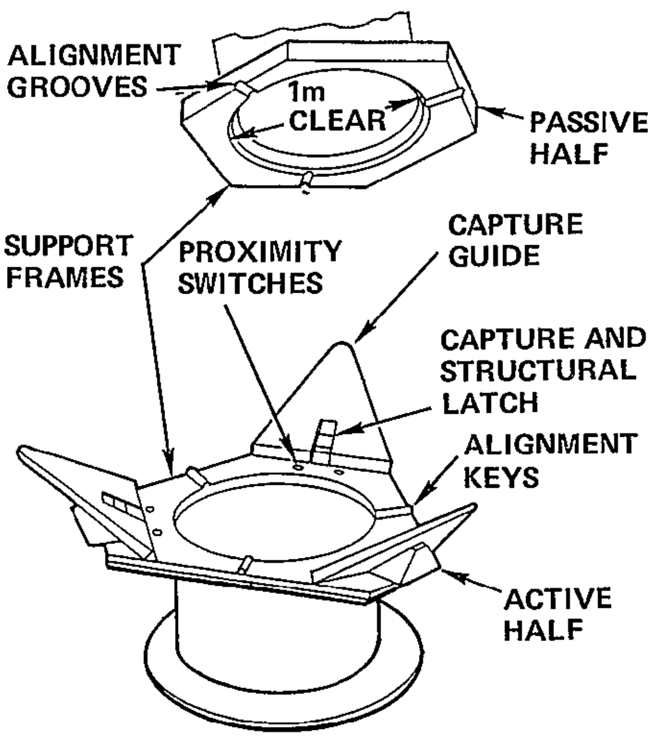
HEXAGONAL FRAME — BERTHING INTERFACE MECHANISM

VF0584



CHARACTERISTICS:

- SIMPLIFIED HEXAGONAL PASSIVE SYSTEM
- HEXAGONAL FRAME ACTIVE SYSTEM WITH 3 CAPTURE GUIDES
- REDUCED PHYSICAL ENVELOPE AND WEIGHT WITHIN PERFORMANCE REQUIREMENTS
- SELF-ALIGNING WITH DUAL-MOTOR ACTUATORS FOR STRUCTURAL RIGIDITY
- INCORPORATES MANUAL OVERRRIDE
- PROVIDES 1.0-m OPENING FOR CREW PASSAGE

SELECTION CRITERIA

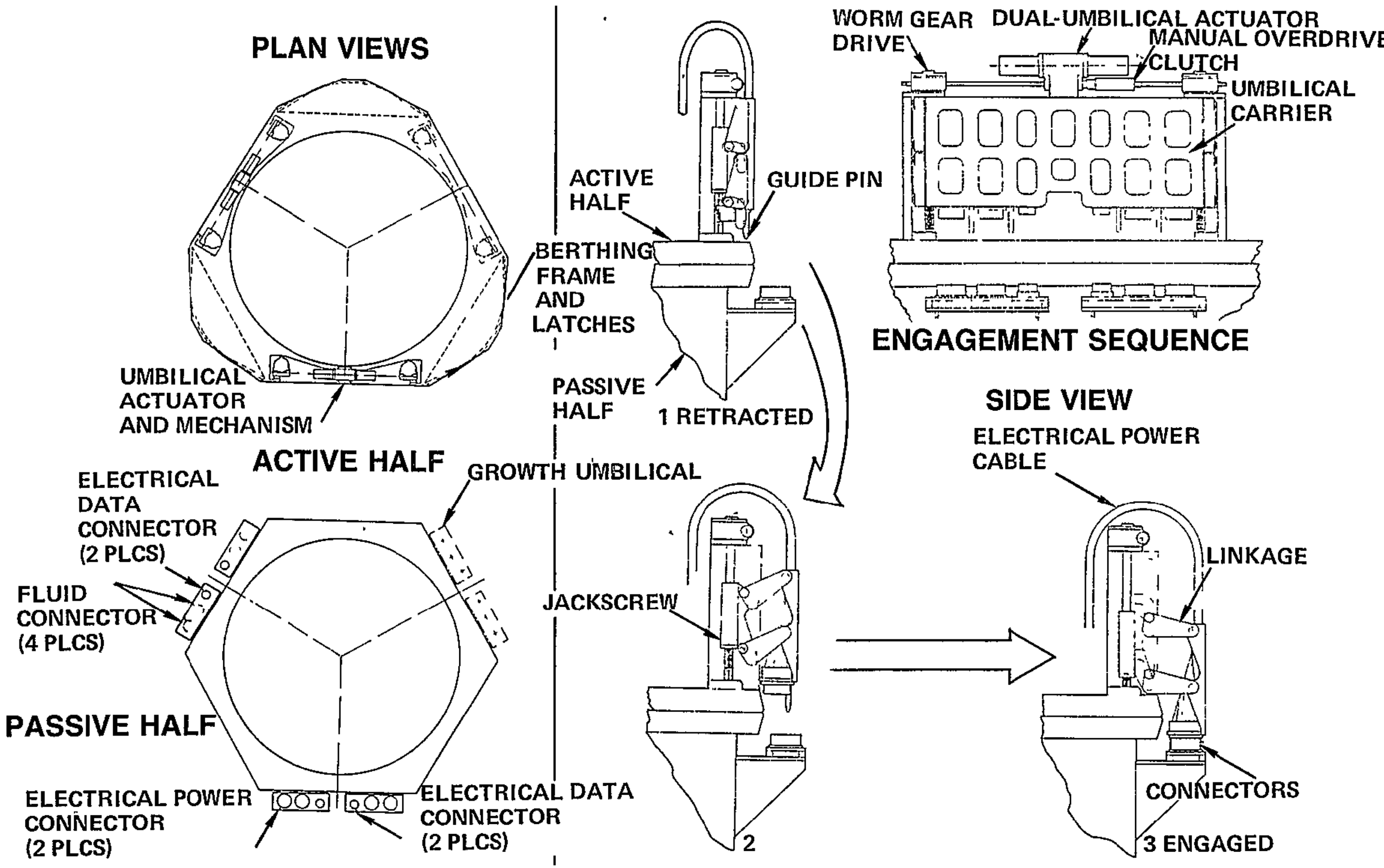
- SMALLER PHYSICAL ENVELOPE PERMITS INCREASED VOLUME MODULES TO FIT IN CARGO BAY
- CAN BE USED ON ALL STATION ELEMENTS INCLUDING BOTTOM OF SPACELAB PALLETS CARRYING PAYLOADS
- REDUCED COMPLEXITY IMPROVES RELIABILITY AND MINIMIZES EVA MAINTENANCE
- DEVELOPMENT UNIT FABRICATED BY MDAC-HB FOR JSC TESTING
- COST ESTIMATED TO BE LESS THAN THAT OF COMPETITORS

DESIGN CRITERIA

- ACCOMMODATE LARGE VEHICLE INTERFACE MOMENT (16,000 FT-LB IN PITCH AND YAW) ORBITER-ORBITER CONTINGENCY DOCK

VFO583

BERTHING UMBILICAL INTERFACE



HABITABILITY MODULE — CONCEPT FORMULATION (INTEGRATION)

VFO360

Four Rack Payload Vol Reqmt

Crew Size Option Analysis (2-3 Max)

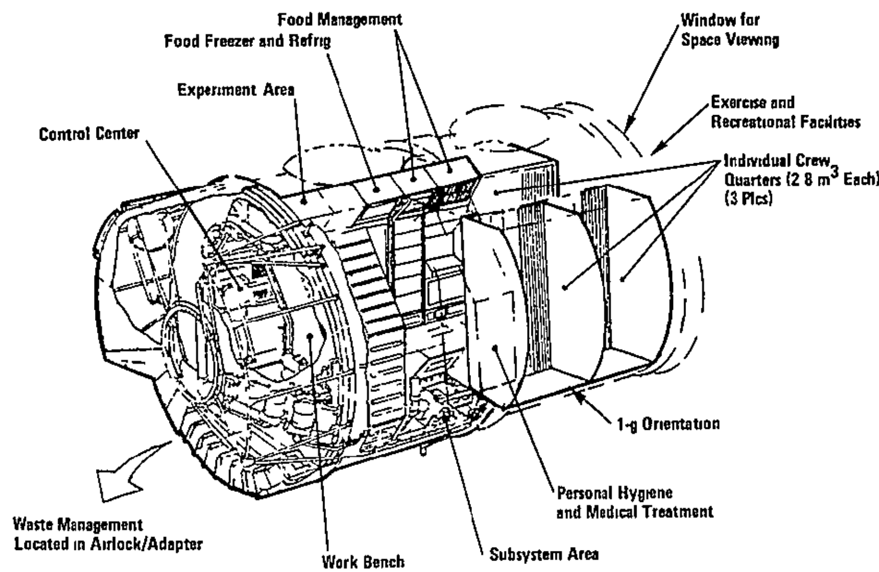
Concept Formulation (Elements) Results

Volume Allocation Analysis

"Outhouse" Waste Mgt Decision

High-Comfort Crew Qtrs Volume Decision

Habitability Interior Arrangement Design Features



Cost Analysis (Min Mods)

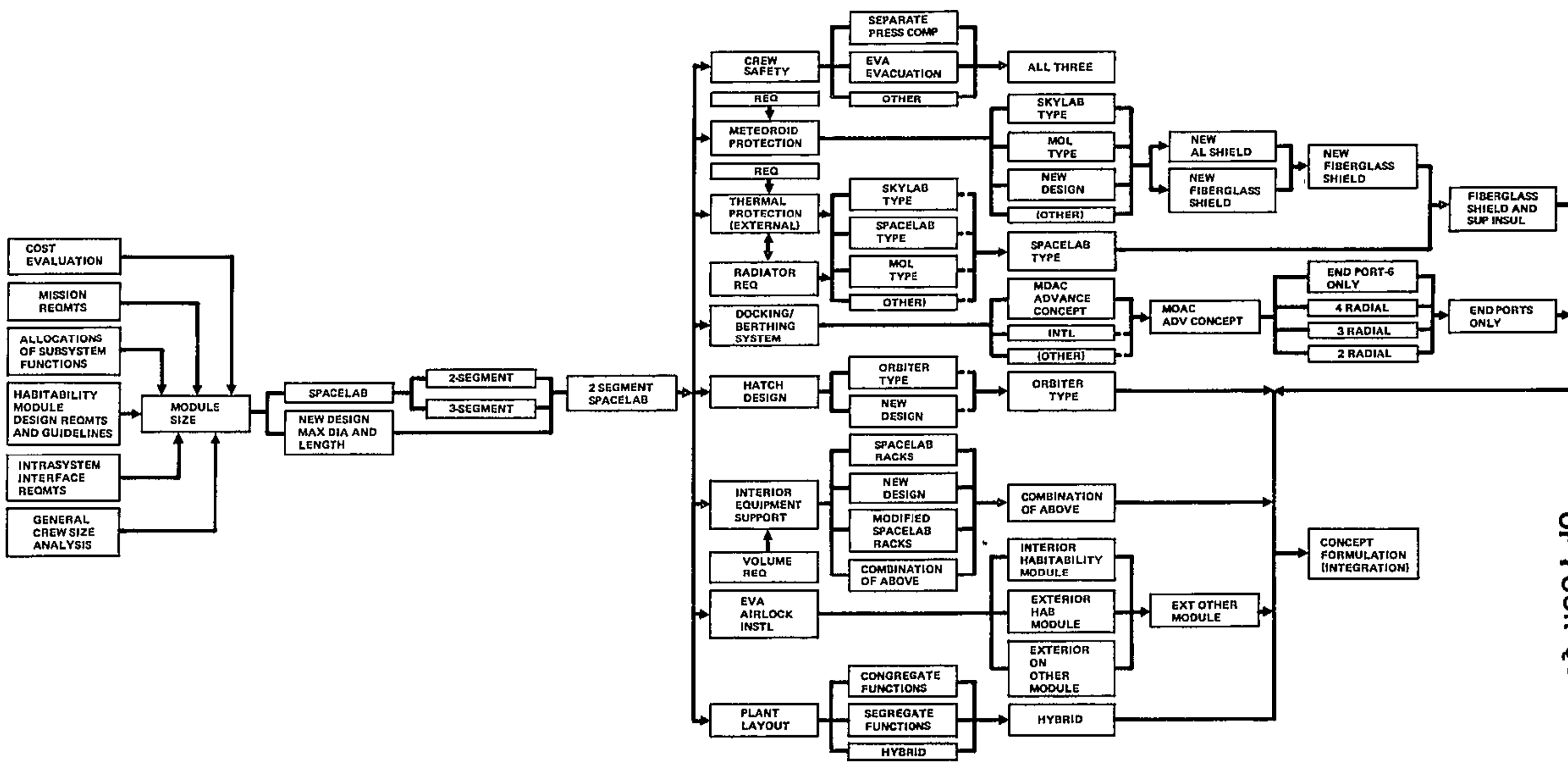
Mass Properties Analysis

Operational Scenario Analysis

Detail Design

HABITABILITY MODULE CONCEPT FORMULATION (ELEMENTS)

VFO361



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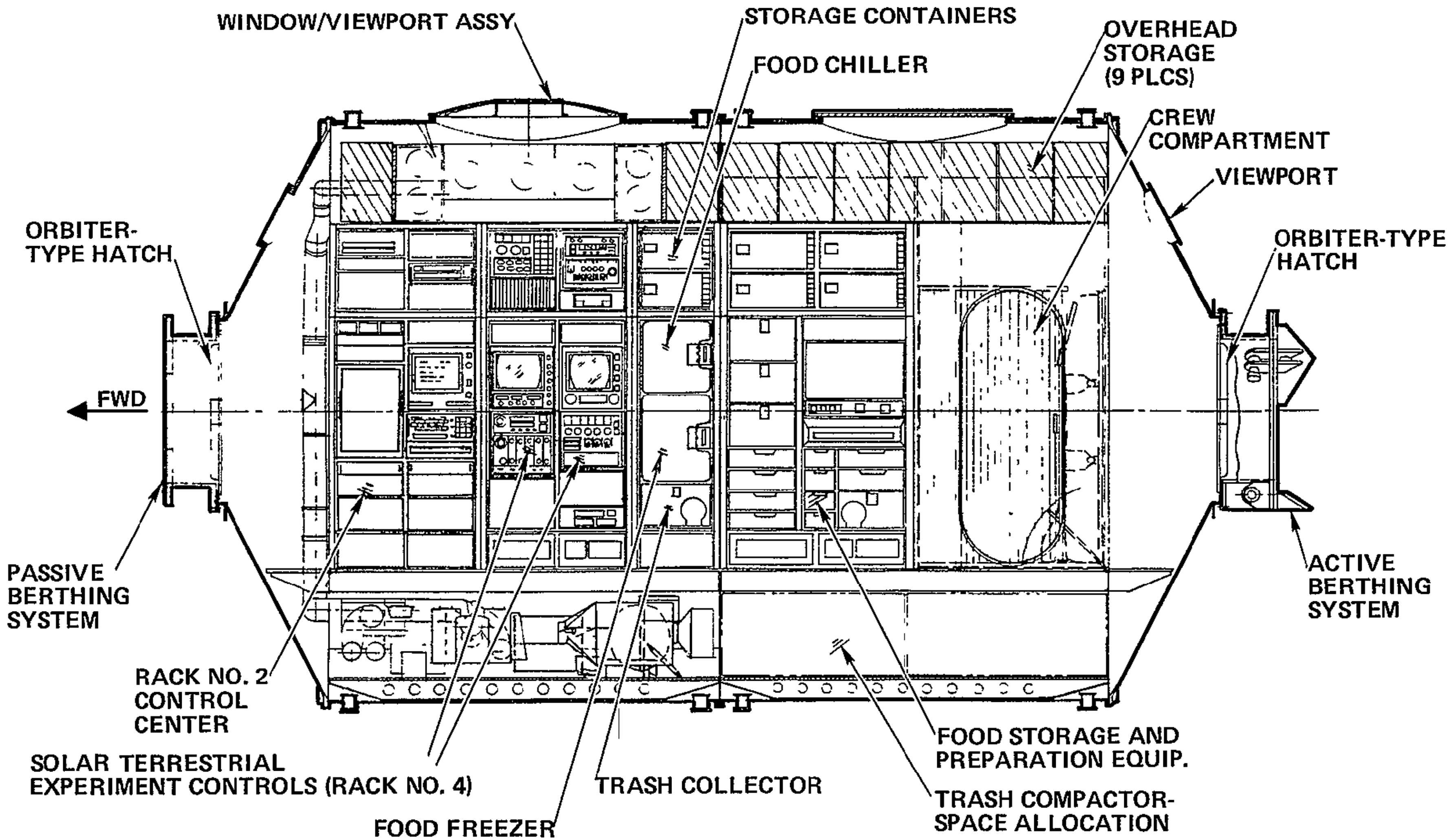
VFO485

HABITABILITY MODULE INBOARD PROFILE
(STARBOARD SIDE)



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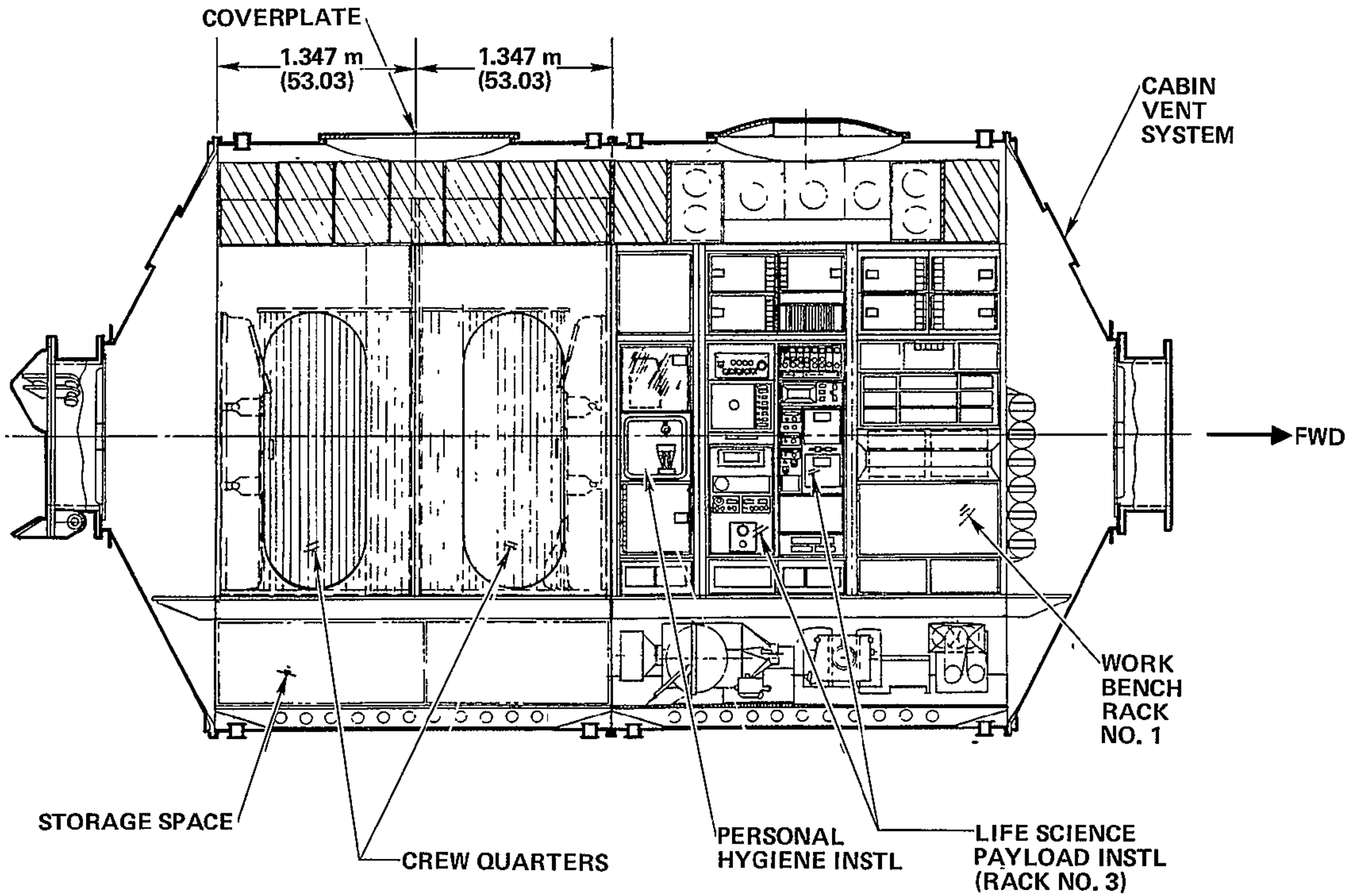
HABITABILITY MODULE INBOARD PROFILE (PORT SIDE)

VFO484



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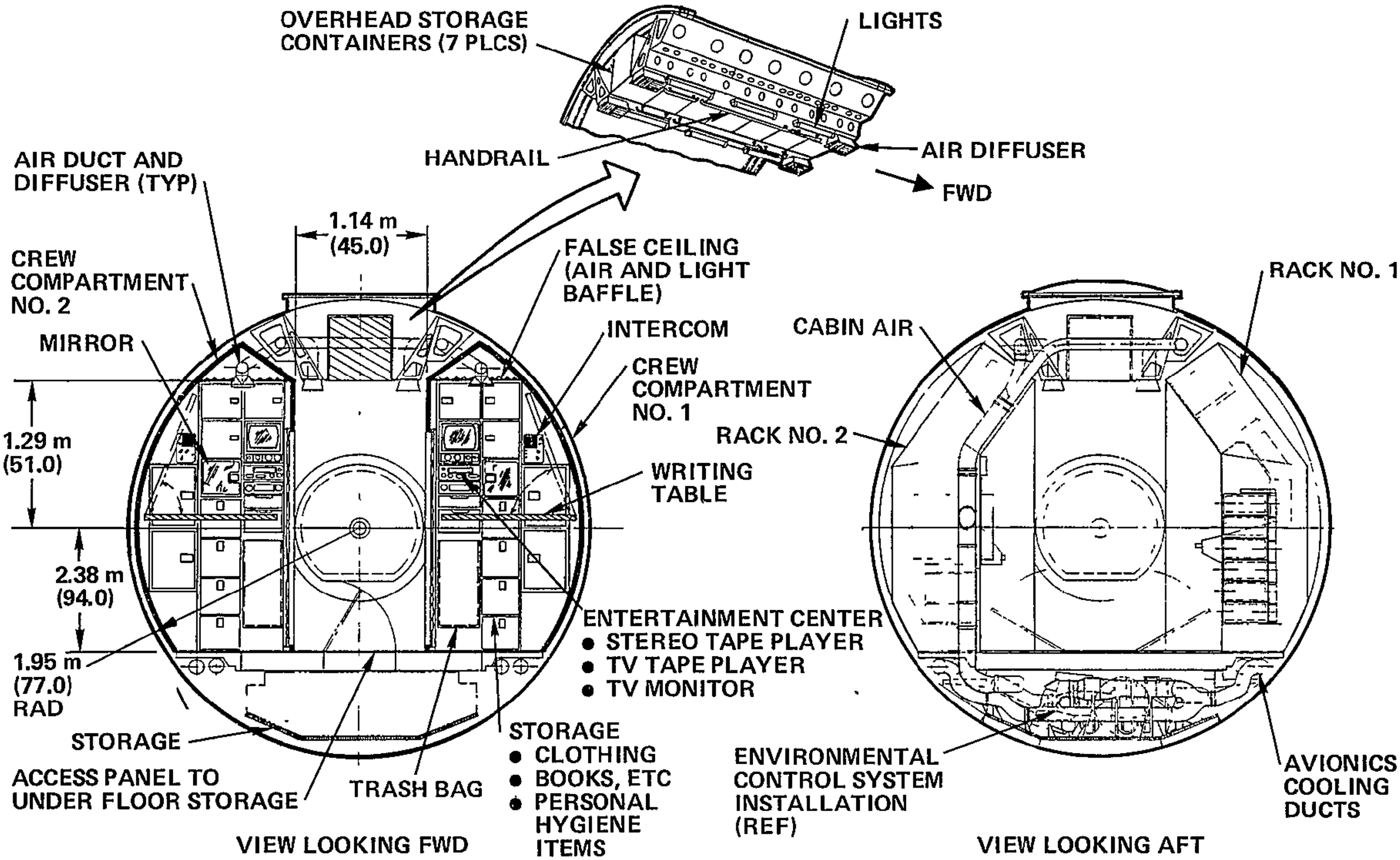
VFO483

HABITABILITY MODULE INBOARD PROFILE



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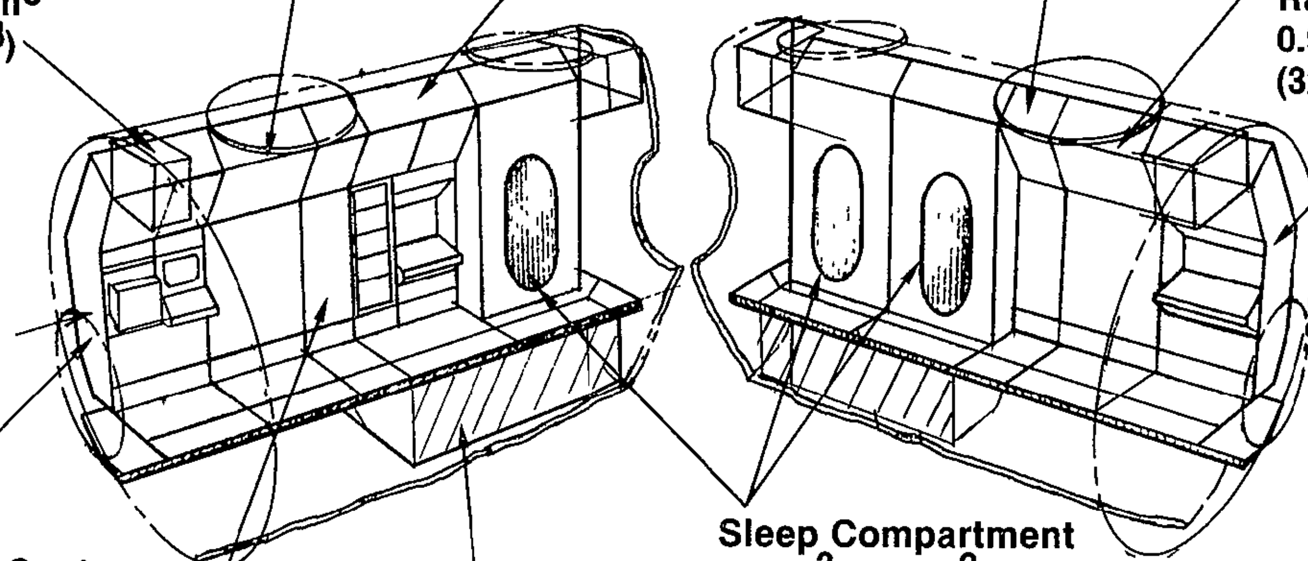
VOLUME AVAILABILITY (2-SEGMENT, 3-MAN MODULE)

VFO406



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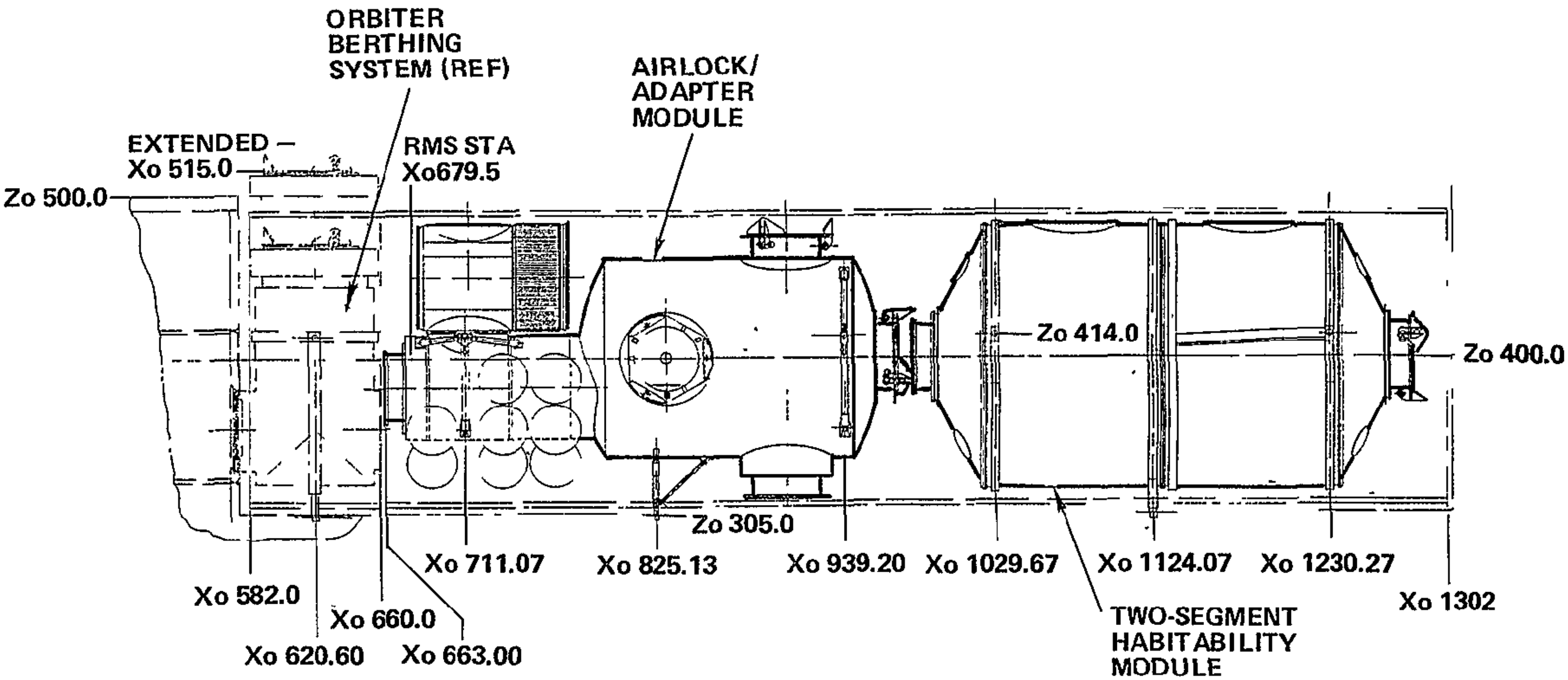
CARGO BAY ARRANGEMENT AIRLOCK/ADAPTER AND TWO-SEGMENT HABITAT

VFO389



STRUCTURAL/MECHANICAL CONCERNS

VFO735

Spacelab Module

- End Dome Strength For Docking Loads
- 10-Yr Life Limitations

Airlock/Adapter Module

- High Pressure System Design Assurance
  - Design Factors of Safety
  - Fracture Mechanics Analysis
  - Meteoroid Penetration Protection
- Airlock Fatigue Life

Assembled Platform

- Docking Joint Compliances Increase Assembly Flexibility (Dynamics/Control Problem)
- Thermal Distortions Affecting Pointing Requirements
- Design For "Leak-Before-Failure" Condition to Preclude Catastrophic Pressure Loss
- Reboost Loads on Modules and Connections

REQUIRED STRUCTURAL/MECHANICAL TASKS

(This Contract)	• Define Design Factors of Safety For All Platform Components
(Follow-On)	• Estimate Maximum Hole Diameter in Spacelab Module for "Leak-Before-Failure" Design
(Follow-On)	• Review Spacelab Module Design For Life Limitation Components
(Follow-On)	• Perform Preliminary Fracture Mechanics Analysis on Spacelab Module (See Example Statement of Work Provided to ERNO For FOD Study. Analysis Not Performed Since US Capability Is Required)

FOLLOW-ON FRACTURE MECHANICS ANALYSIS*

VFO738

(ONLY PRELIMINARY TYPE REQUIRED)

Objective Assure That No Major Mods Are Required for Spacelab Module

- Establish the Maximum Flaw Size That Can Exist After Proof Tests
- Determine the Design Fatigue Spectrum For the Pressure Shell, Limit Design Stresses, Temperature, and Cycles/Time For the Following Mission Regimes:
  a) Ground
  b) Prelaunch
  c) Launch and Ascent
  d) On-Orbit (As a Function of Duration and Repeat Flights)
- Determine the Maximum Flaw Growth After the Proof Tests Using Available Material (MDAC) Flaw Growth Rate Characteristics and the Design Fatigue Spectrum (Using a Factor of 4 on Design Cycles)
- Demonstrate Either of the Following With Analysis Results:
  a) Maximum Flaw After Proof Test Does Not Grow Through the Thickness or Become Critical
  b) The Flaw Does Grow Through the Thickness But Does Not Become Critical (E.G., Leak Before Fail Condition). If This Condition Occurs, Show That Spacelab Atmosphere Leakage is Very Low and Can Be Detected Before Endangering the Crew

*Using MDAC-Modified MSFC Code (Used Recently on SRB)

LOGISTICS WEIGHT AND VOLUME REQUIREMENTS — 180-DAY RESUPPLY CYCLE — THREE MEN

	Weight (Lb)	Volume (Ft^3)
Basic Sustenance		
■ Shelf Stable Food	(3.6/Man-Day)	139
■ Frozen Food	(1.0/Man-Day)	54
■ Water	(4620)	80
■ Clothing	(1.6/Man-Day)	54
■ Personal Gear	(TBD)	6 (Est)
*■ Trash Storage (Compacted to 0.38 Ft^3/MD)	(TBD)	206
■ EVA Supplies	(TBD)	100 (Est)
■ Maint and Housekeeping Supplies	(4.0/Day)	50
■ MSP Spares	(TBD)	100 (Est)
■ ECLS Supplies	(TBD)	(TBD)
Early Payloads (+ or)		
■ Life Science	(TBD)	50.0 (Est)
■ Material Processing	(TBD)	32.0 (Est)
■ Solar/Terrestrial	(TBD)	50.0 (Est)

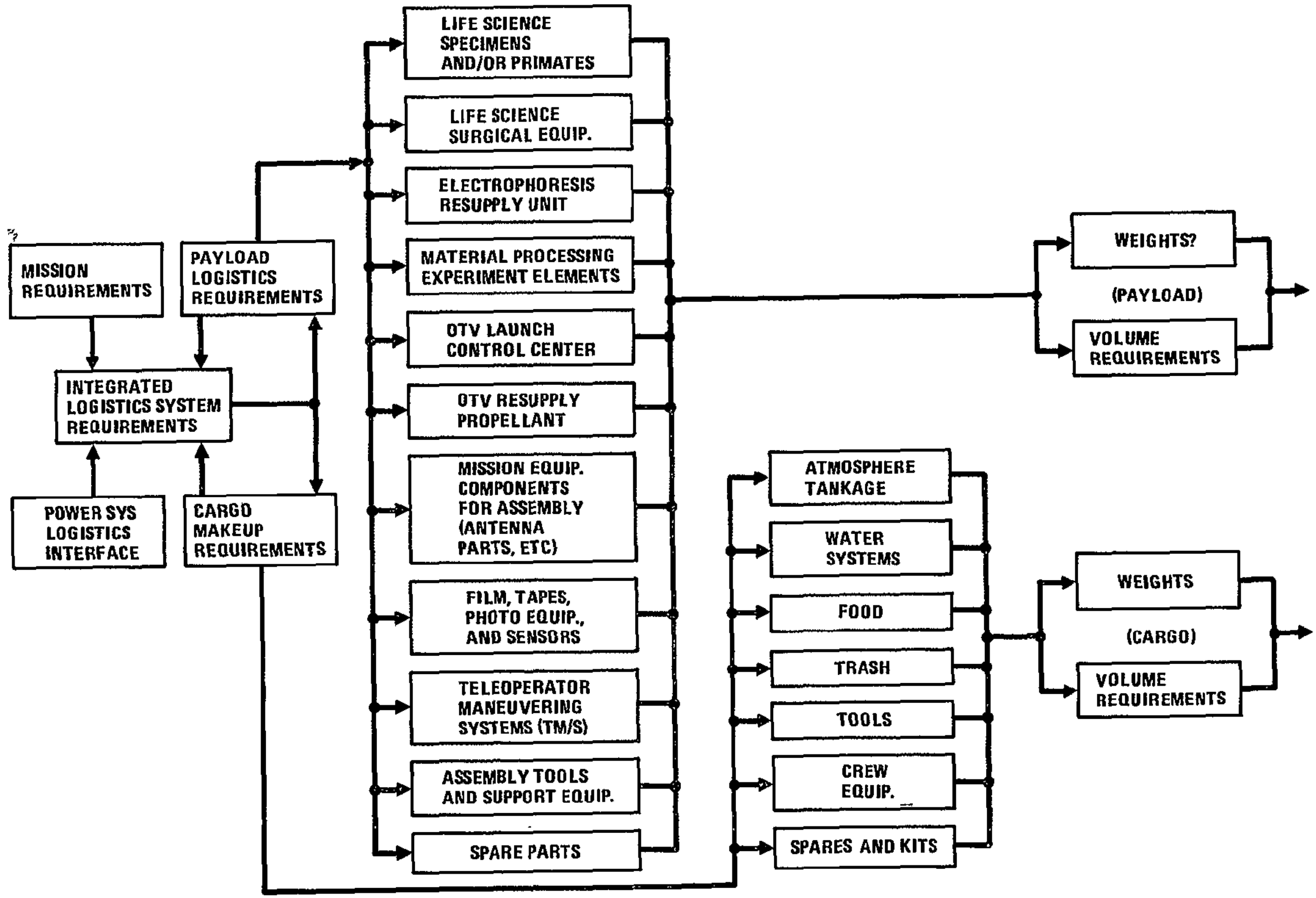
Logistics Module Concept

Logistics Module Design

*This Volume Can be Used for Other Purposes During Delivery to Orbit — But is Reserved for De-Orbit Trash

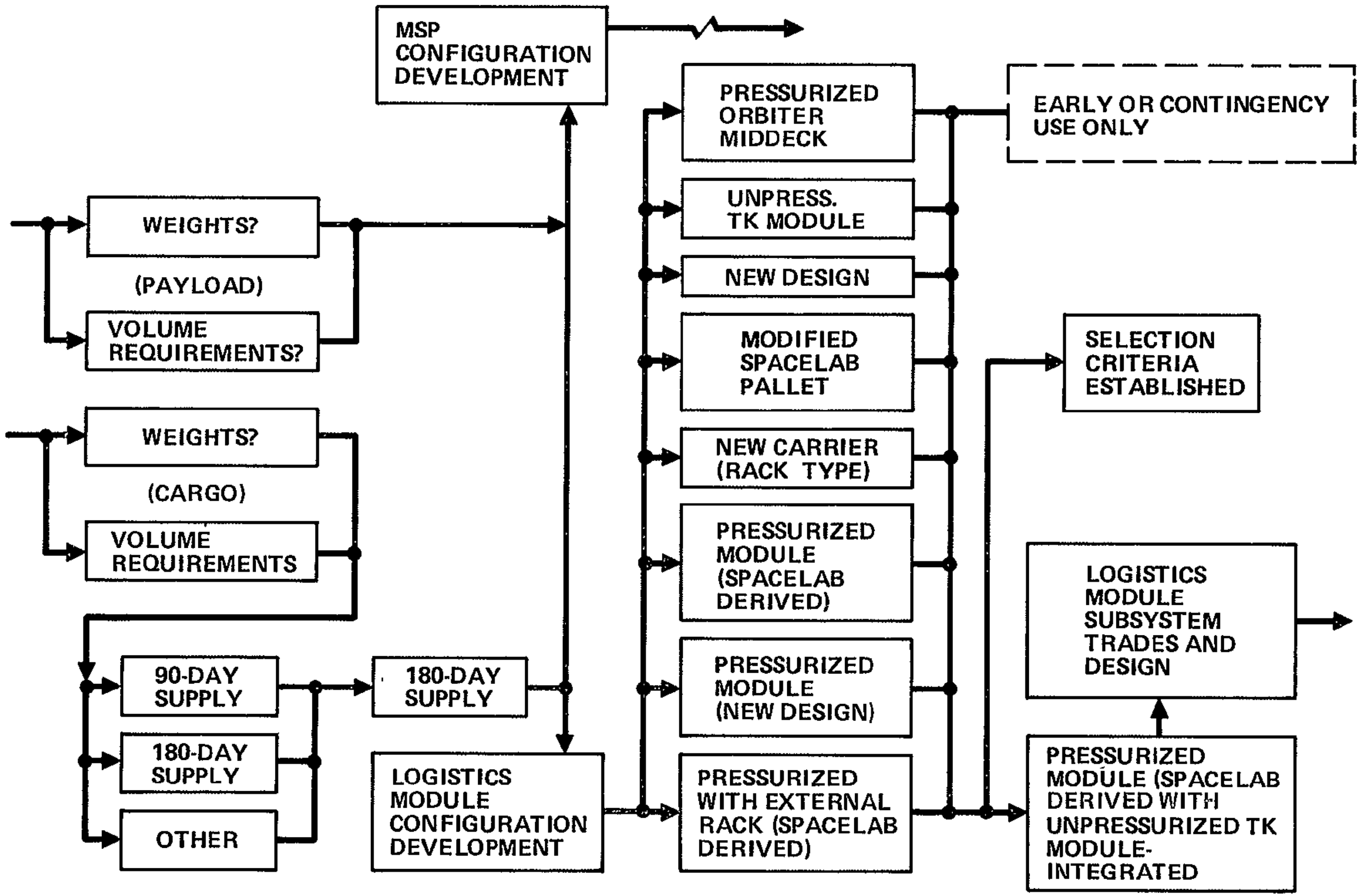
CONCEPT FORMULATION FLOW
LOGISTICS SYSTEM

VFO385



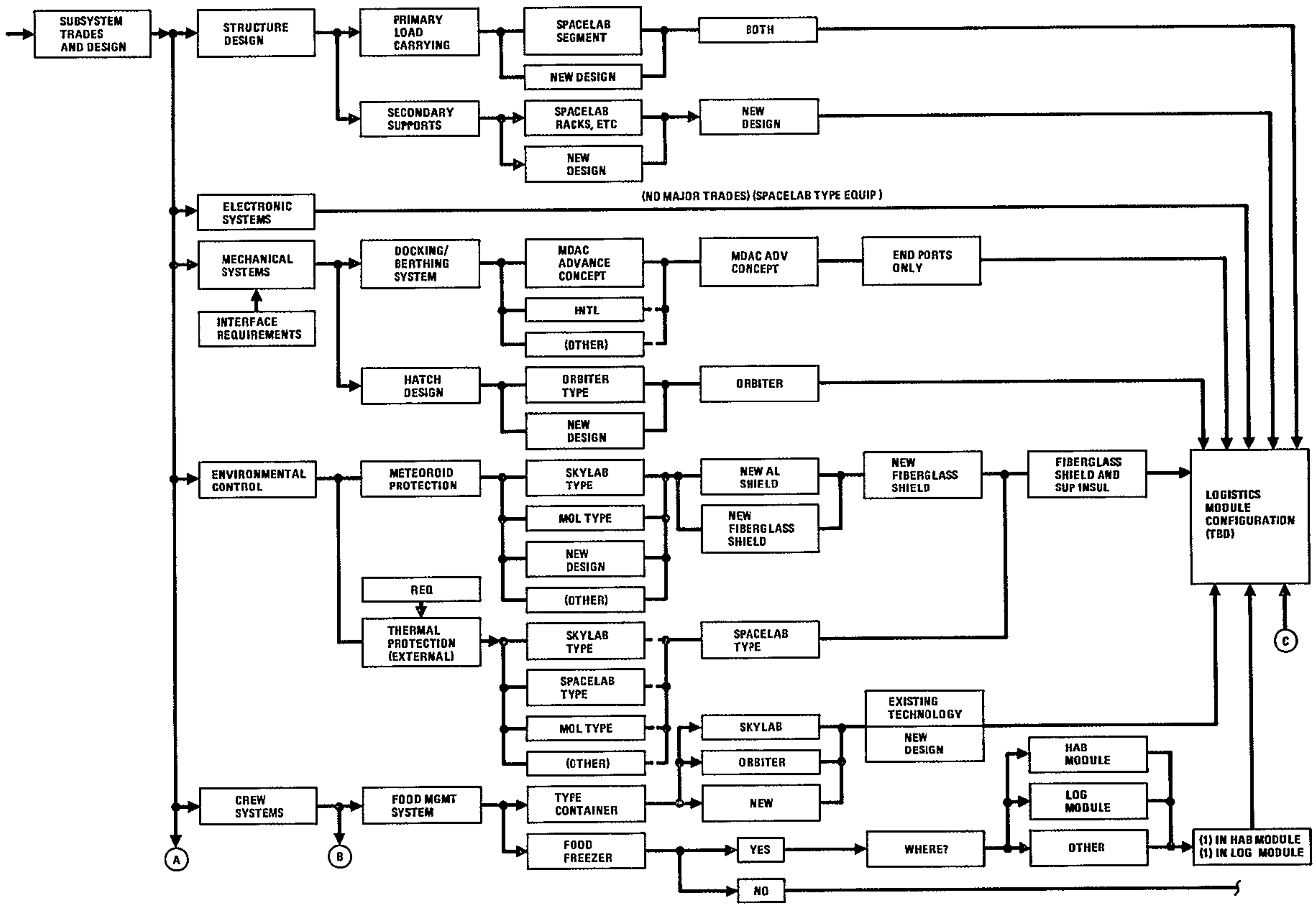
CONCEPT FORMULATION FLOW LOGISTICS SYSTEM (CONT)

VFO388



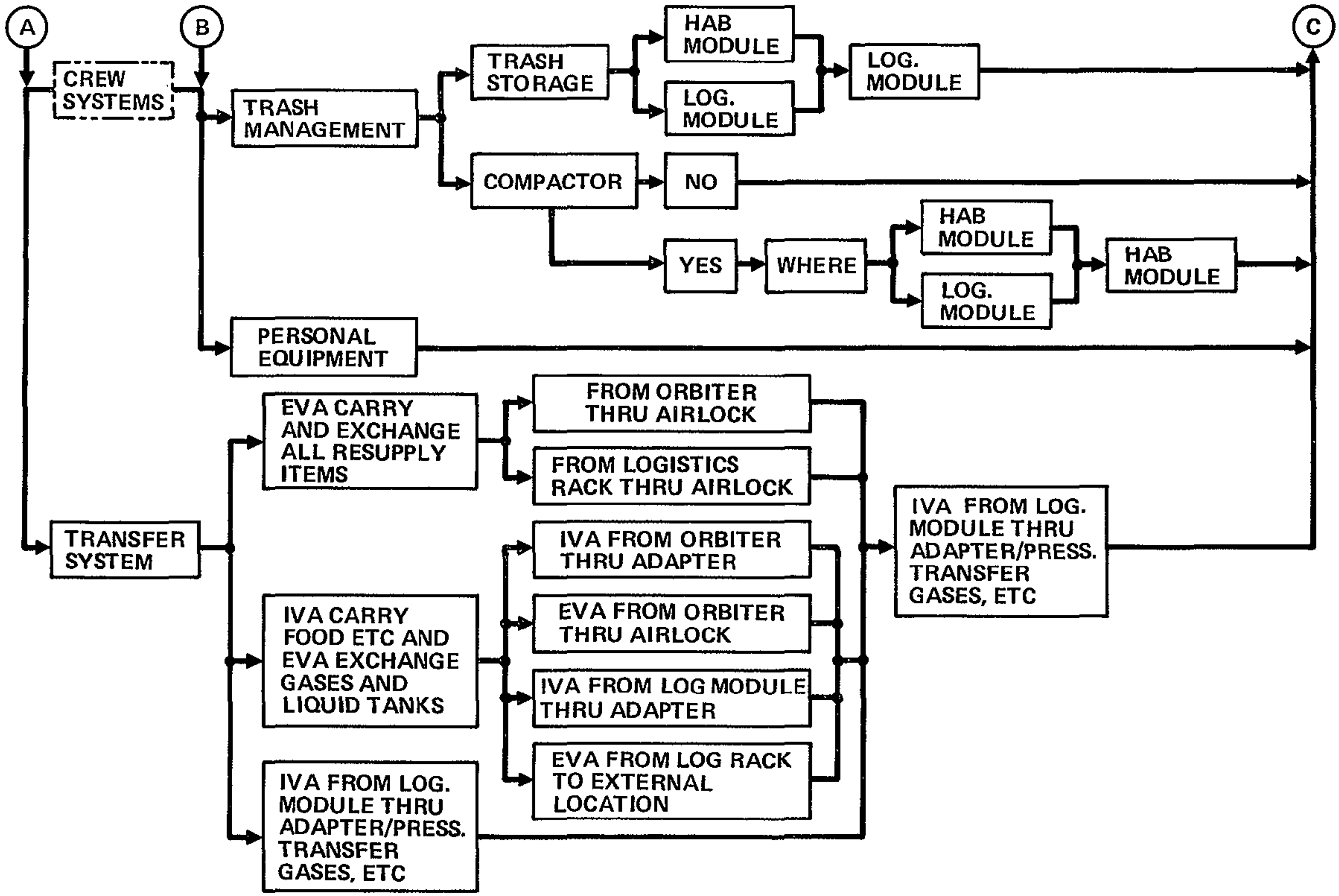
CONCEPT FORMULATION FLOW LOGISTICS SYSTEM (CONT)

VFO386

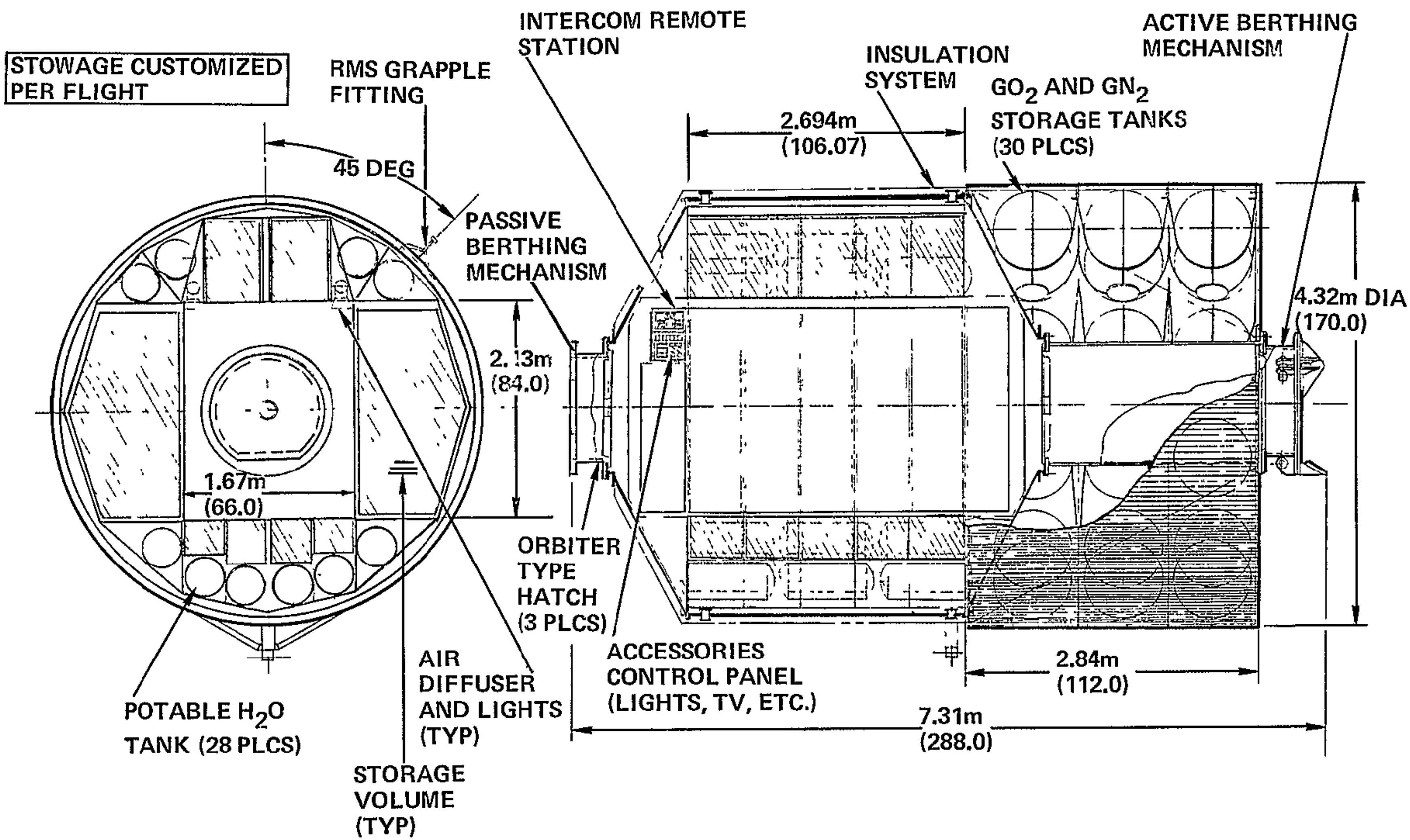


CONCEPT FORMULATION FLOW LOGISTICS SYSTEM (CONT)

VFO387

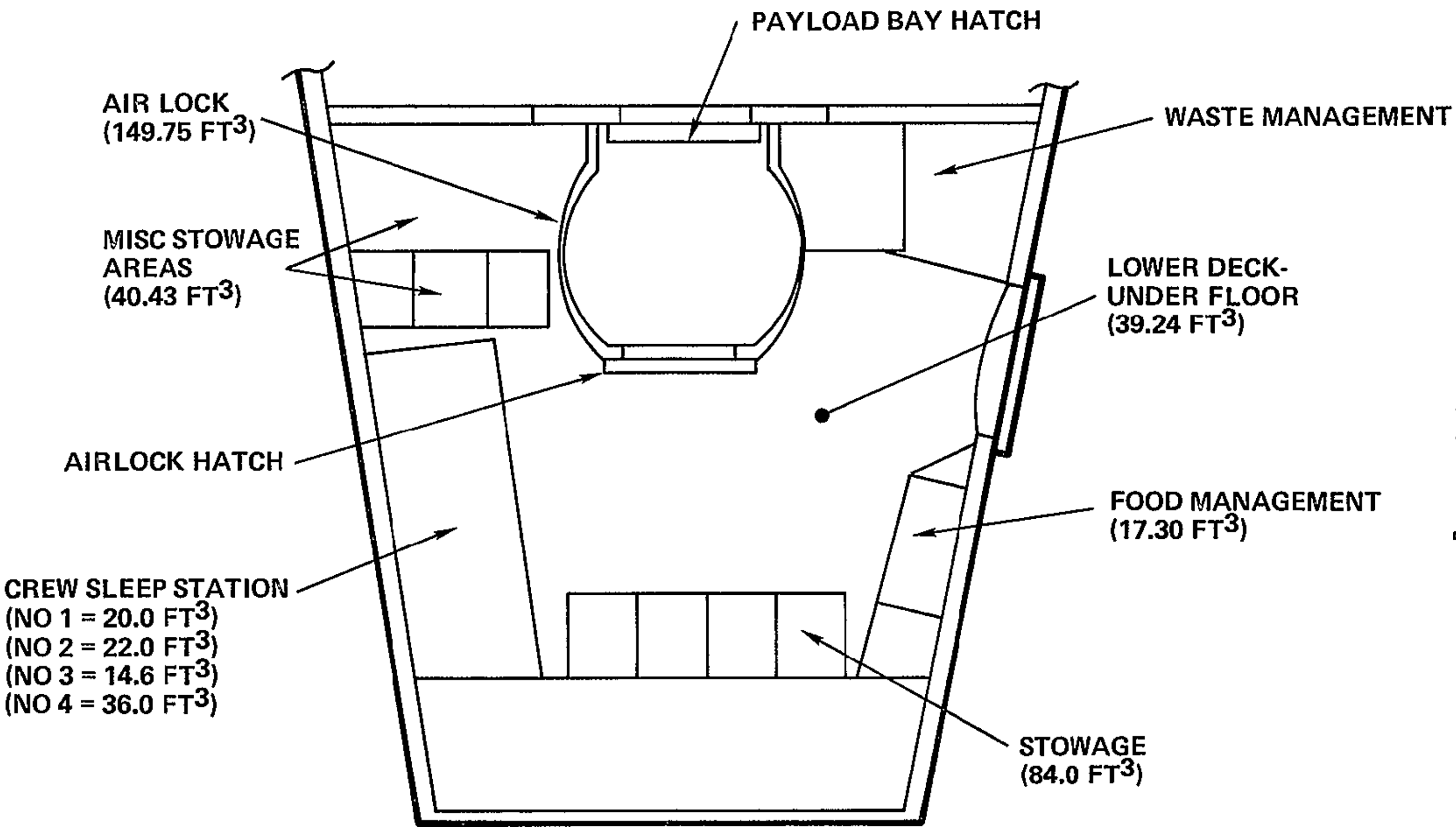


LOGISTICS MODULE — 180-DAY CONFIGURATION



ESTIMATED ORBITER LOGISTICS STOWAGE VOLUME MID-DECK

VFO759



TOTAL MID AND LOWER DECK = 423.32 FT^3

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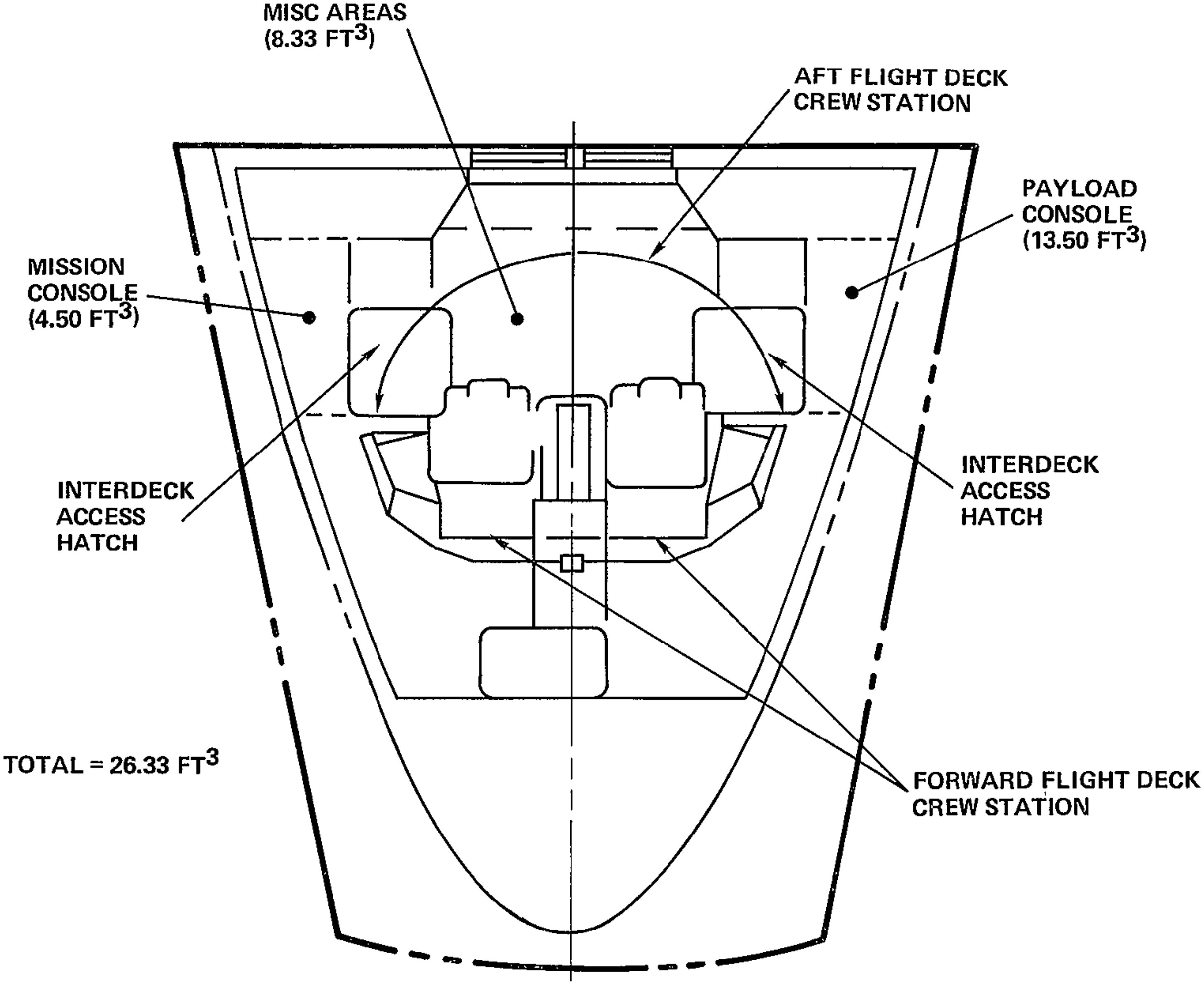
ESTIMATED ORBITER LOGISTICS STOWAGE VOLUME FLIGHT DECK

VFO758



TOTAL = 26.33 FT^3

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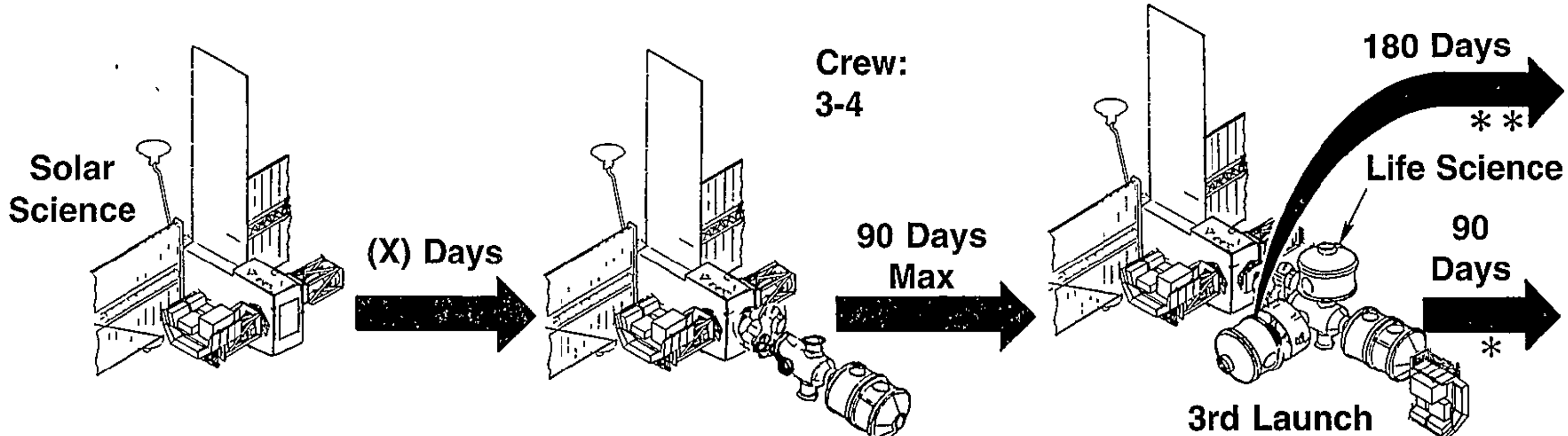
CANDIDATE DELIVERY FLIGHT SEQUENCE



1st Launch

- Power System
- One Solar Payload Pallet (Full Cargo Bay) (32,000 Lb)

2nd Launch

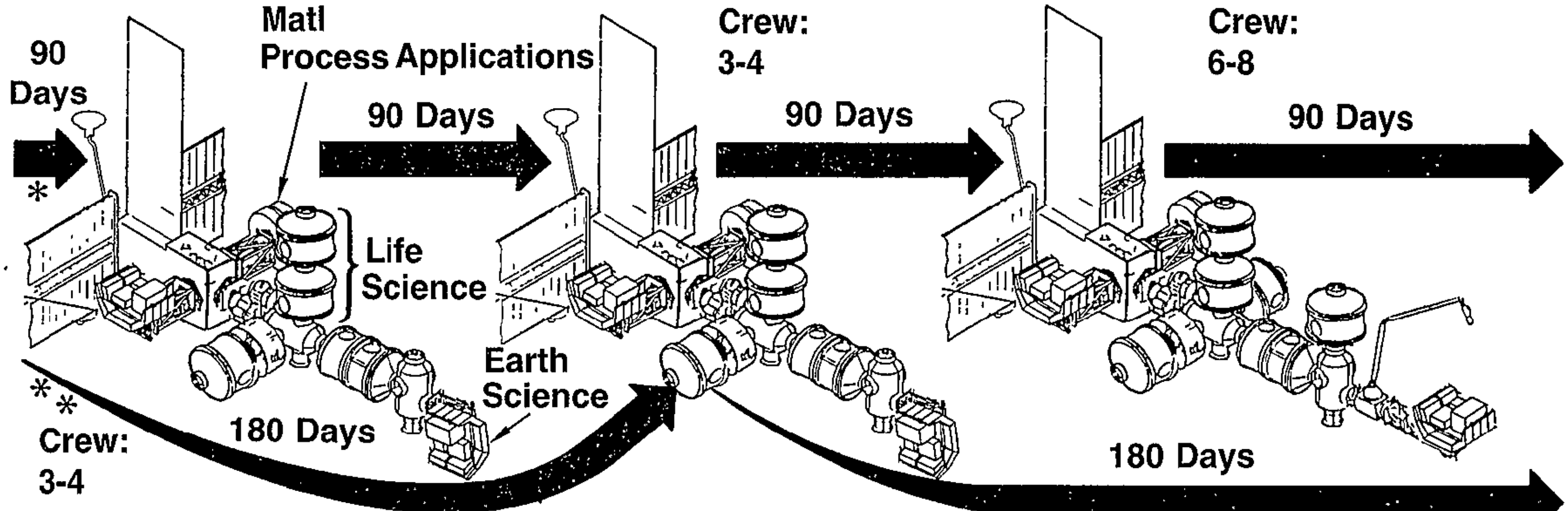
- Airlock/Adapter (90 Days' Supplies + 30-Day Contingency)
- 3-Man, 2-Segment Control/ Habitat Module
- First 3-Man Crew (Full Cargo Bay) (~33,000 Lb)

3rd Launch

- Logistics Module (Sized for 180 Days' Supplies)
- Life Science Payload (1-Segment Module)
- Earth-Looking Payload (One Pallet)
- Short Payload Operations Beam with 360-Deg Rotation
- Exchange Crew (Full Cargo Bay) (~29,000 Lb)

CANDIDATE DELIVERY FLIGHT SEQUENCE (CONT)

VFO363



4th Launch	5th Launch	6th Launch
• Life Science Payload (1-Segment Module) • Material Processing Payload (One Module) • New 3-Man Crew (Orbiter Provides Storage Space in Middeck for Unprogrammed Logistics) (Room for Other Payload Delivery) (~20,000 Lb)	• Logistics Module • New Crew • Payload Support Adapter (Airlock/Adapter 11) • (Full Cargo Bay) (~26,000 Lb)	• One-Segment, 3-Man Habitability Module • 1-Segment Payload Module • Payload Operations Beam/RMS • (Orbiter Provides Middeck Storage for Logistics) • Add 3 Men to Crew (Full Cargo Bay) (~30,000 Lb)

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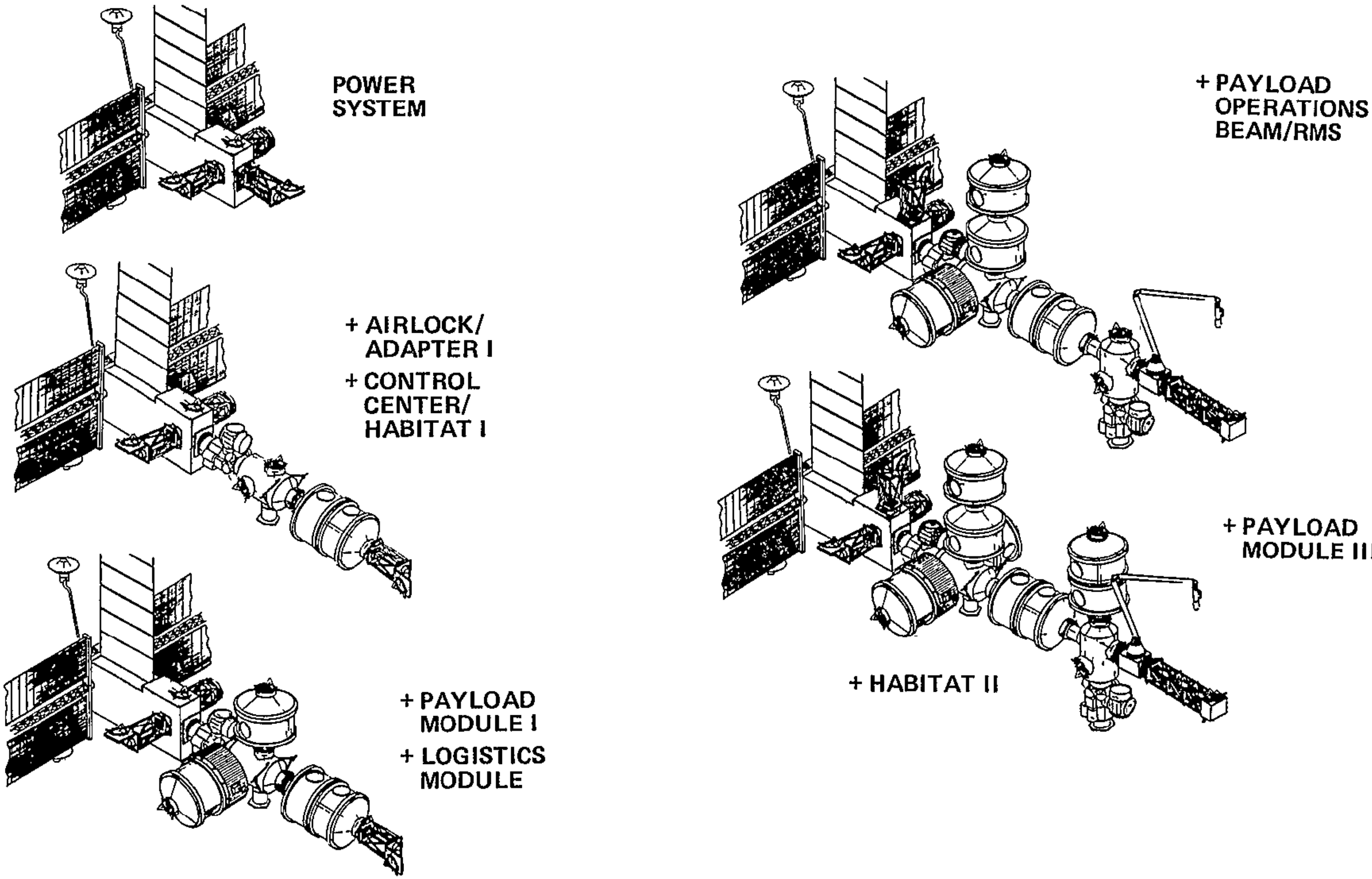
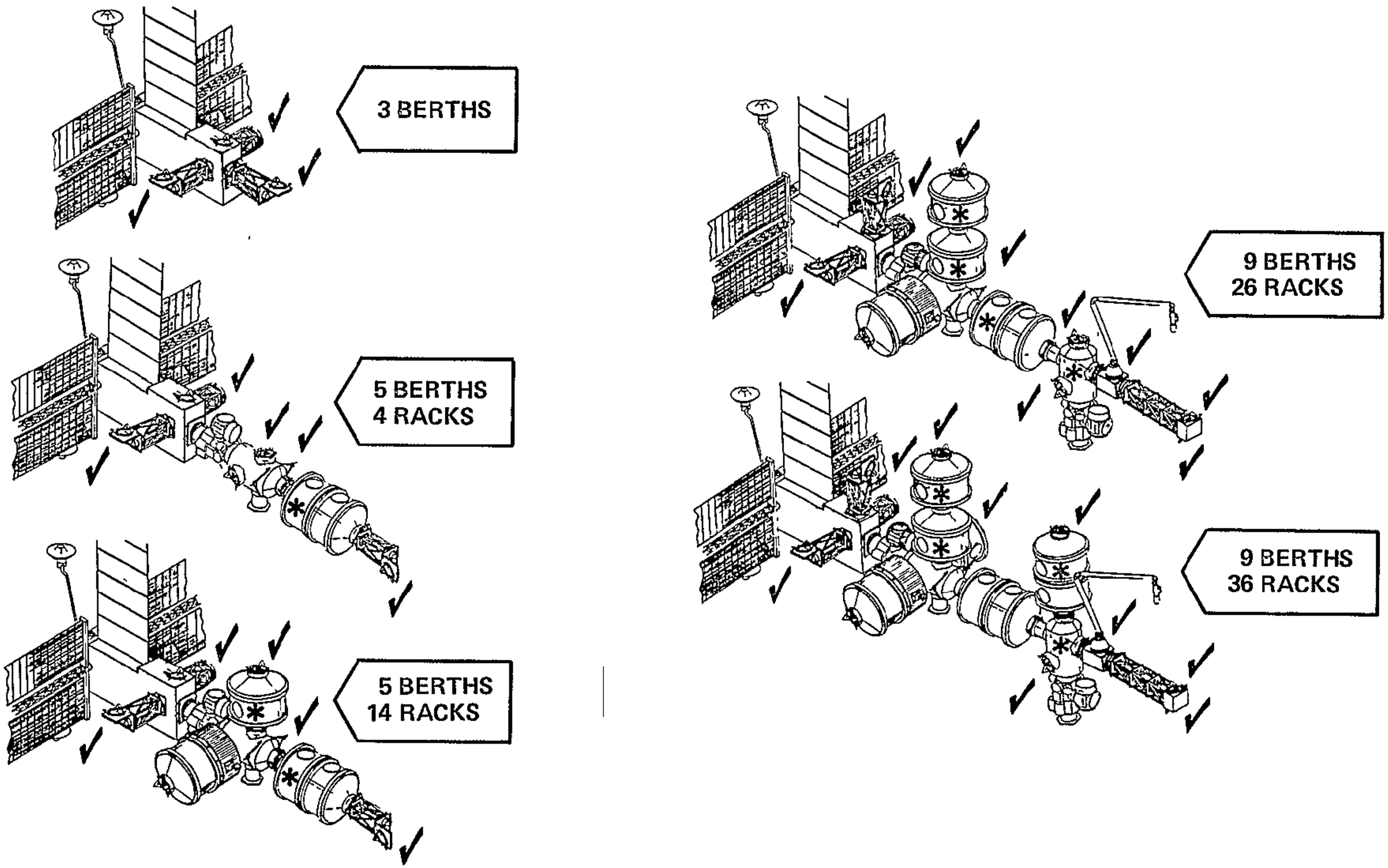
VFO625

SPACE STATION GROWTH



PAYLOAD ACCOMMODATIONS
(✓-EXTERNAL BERTHS,* INTERNAL RACKS)

VF0251



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OTV/PLATFORM OPERATIONS AND FACILITIES

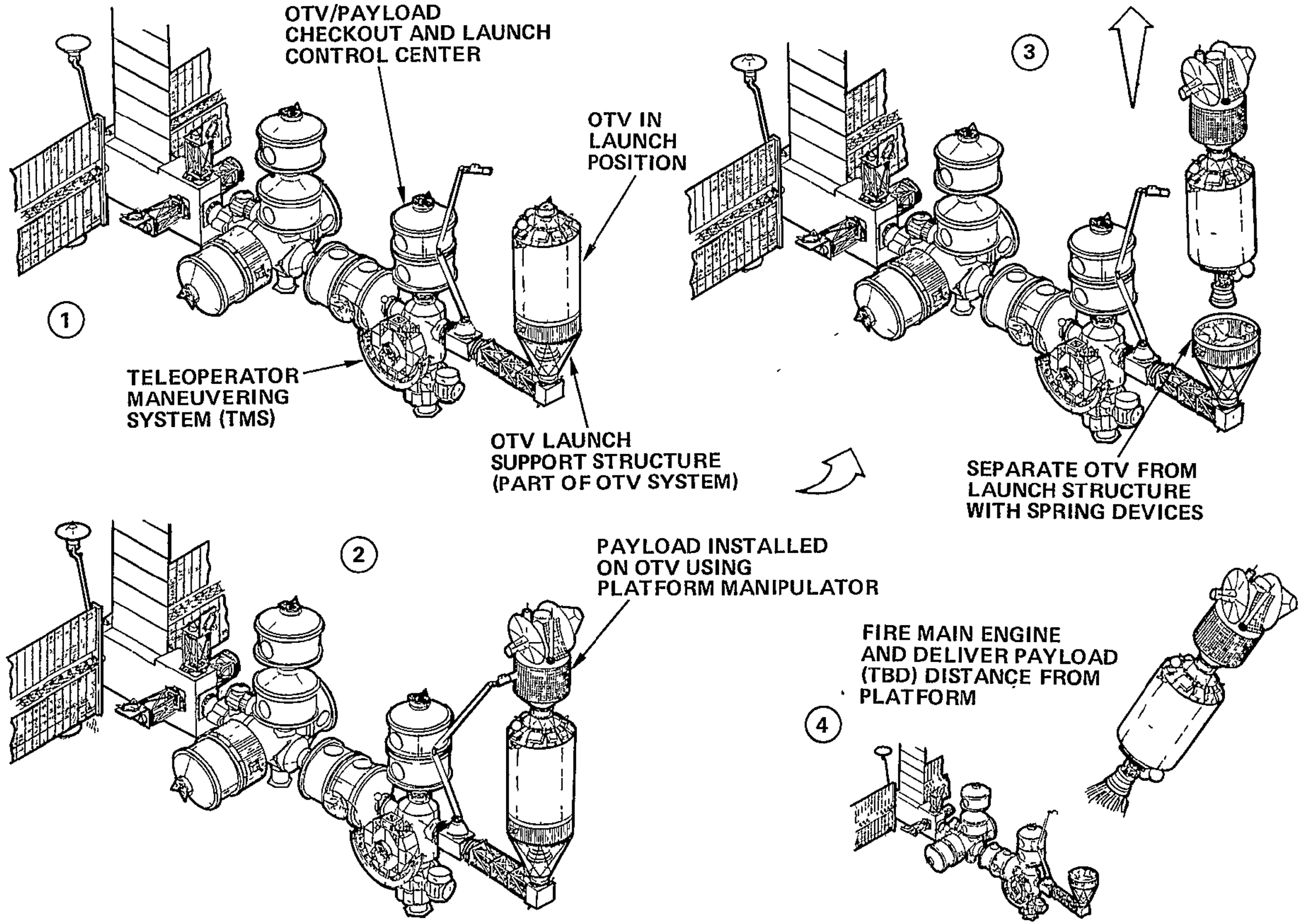
VFO734

- Manipulation and Berthing of Large and/or Multiple OTV Propellant Tanks and Payloads
- OTV (RE)Fueling
- Resupply Other Expendables (I.E., Gases, Batteries, Hydraulic Fluid)
- OTV Checkout — Maximize Self-Checking
- OTV Maintenance — Simple Functions Only

- Propellant Storage/Transfer Tanks
- Propellant Transfer Equipment
- Pressurant Transfer Equipment
- Platform/OTV Umbilical
- Checkout Console
- Checkout Support Equipment
- Control Center
- Remote Manipulator System for Payload Interchange

OTV OPERATING SCENARIO (LAUNCH SEQUENCE)

VFO680



VF0733

OTV CHECKOUT ON PLATFORM

Subsystems

Propulsion

- Leak Checks
- Valve Functional Checks
- Instrumentation Calibration

Thermal

- Insulation
- Heaters

Mechanical

- Engine Gimbaling
- Berthing Mechanism — Separation
- Payload/OTV Separation and Berthing

Electrical

- Power Subsystem Checkout
- Guidance and Navigation Subsystem
- Telemetry and Comm System

Avionics

- Data Management Subsystem
- Computer C/O

How Different From Ground?

- Limited (or No) On-Line Replacement of Hardware
- Multiple Firing (Use of Cryogenic Engines with Minimum C/O
- Limited Crew Size — Maximize Self-Checking and Computer C/O
- On-Orbit Updating of Controls Software
- Limited Data Processing Capability
- Limited Power Resources
- Limited Capability For Cooling Electronics

PLATFORM/OTV CHECKOUT OPERATIONS

Postmate Checks of OTV With Launch/Test Module (LTM)

- Load Launch Test Module With Test Software
- Apply Test Power to OTV From Test Module
- Verify Communication Between OTV and LTM Computers (Auto Test)
- Limit Check OTV Instrumentation (Auto Test)
- Functional Test/Calibration of Guidance and Navigation System (Auto Test)
- Control System Verification (Auto Test)
- Propulsion System Checks
- RF System Checks (Manual Test)
- Power Transfer Check (Manual Test)
- Ordnance Systems Check (Manual Test)
- Simulated Launch Sequence Test (Auto/Manual Test)

Static Health Checks

- Minimum Power and System Operation
- Limit Checks By LTM Computer to Verify
    - Safe/Arm Status
    - Environmental Status
    - Power System Status

PLATFORM/OTV CHECKOUT OPERATIONS (CONT)

Prelaunch Checks

- Limit Check of OTV Instrumentation (Auto Test)
- Functional Test/Calib of GN&C System (Auto Test)
- Open-Loop RF Checks
- Simulated Launch Sequence Test (Auto/Manual)
- Transfer OTV To Internal Power
- Launch Sequence

Post Launch

- Maintain Communication Via Link
- Verify All Systems Normal Via Limit Check (Auto)
- Verify Normal Engine Start Sequence
- Monitor OTV Performance During Mission
- Record Data For Postmission Analysis

Predocking Checks

- Verify OTV Safe To Dock Via Auto Limit Check
- Monitor OTV Docking Sequence

Postdocking Checks'

- Establish Hardline Comm Link Between LTM and OTV
- Transfer OTV To LTM Power
- Perform Functional Postmate Checks

VFO587

STAGE/PLATFORM INTERFACE EQUIPMENT

Requirements

- Provide Two-Way Command/Response Communication Between the Platform Systems and Crew and:
  - Stage Vehicle (Fly-Away)
  - Interface Equipment (Power, Propulsion, Mechanical, Electronic)
  - Fault Detection and Safing System
- Sequence and Manage all Predeployment Functional Activity
  - Propulsion System Preps
  - Mechanical Unlatch and Erection Systems
  - Stage Vehicle (Fly-Away) Preps
  - Spacecraft Preps (If Required)
  - Ready for Deployment
  - Guidance Update and Readiness
  - Power Systems
- Perform Fault Detection and Automatic Safing

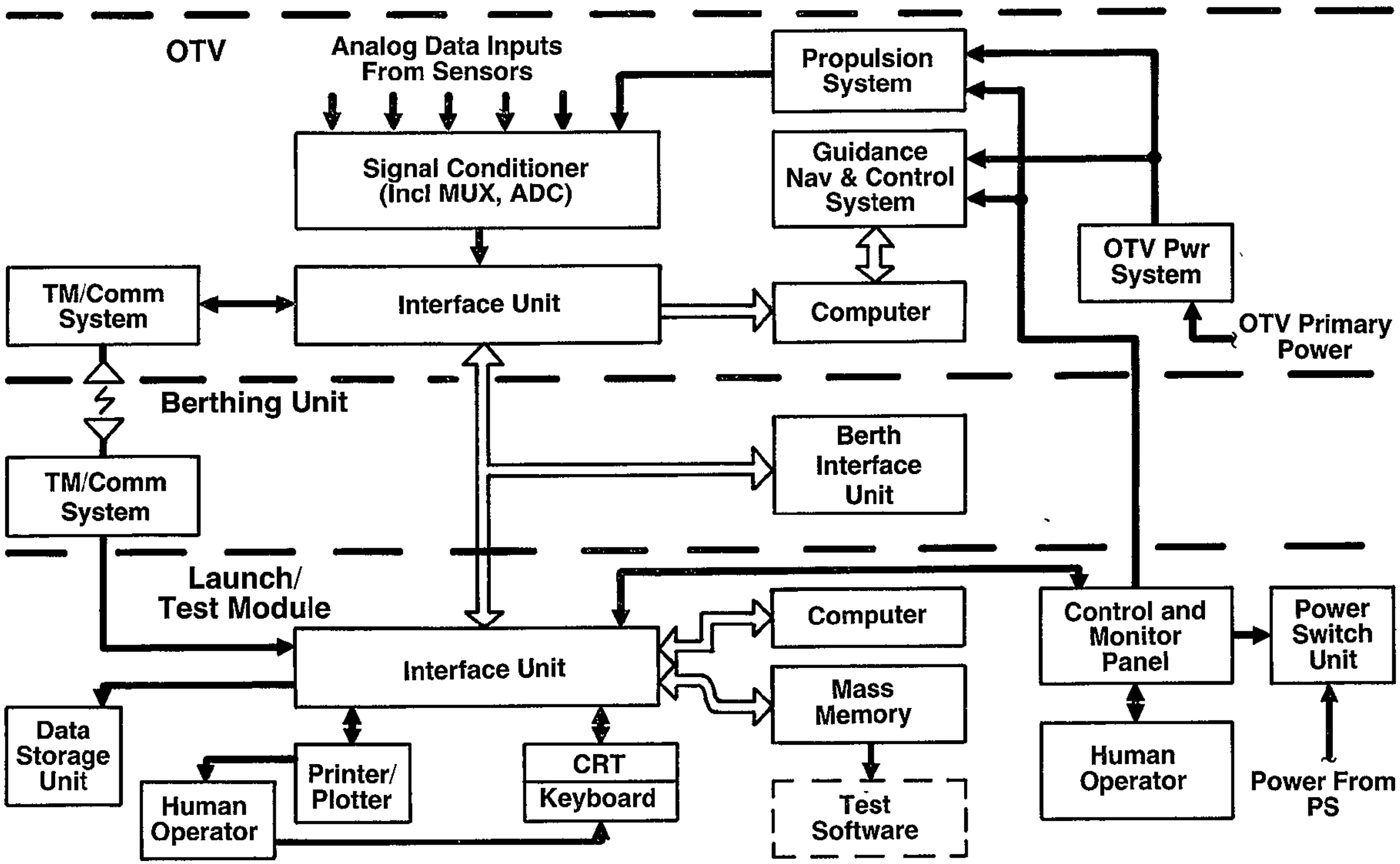
Safety: No Two Equipment Failures or Operator Errors Shall Cause a Catastrophic Condition to Exist While in or Near the Platform

Reliability and Contingency Recovery

- System is Tolerant to Single-Point Failure
- Critical Power Systems Will be Redundant
- Crew Access to Critical Modularized Elements for Adjustment, Maintenance, Repair, or Replacement

VFO731

OTV/LAUNCH TEST MODULE AVIONICS AND INTERFACES



VF0728

SIZE ESTIMATES OF OTV LAUNCH/TEST MODULE EQUIPMENT

	W × H × D (In.)
Interface Unit	20 × 20 × 40
Printer/Plotter	20 × 30 × 20
CRT/Keyboard	20 × 20 × 30
Computer	20 × 20 × 40
Mass Memory	20 × 20 × 40
Power Switch. Unit	20 × 10 × 20
Control & Monitor Panel	20 × 30 × 10
Data Storage Unit	20 × 40 × 30
Resupply Unit	20 × 20 × 30
Telemetry Unit	20 × 20 × 30
Rendezvous Radar Unit	20 × 20 × 40

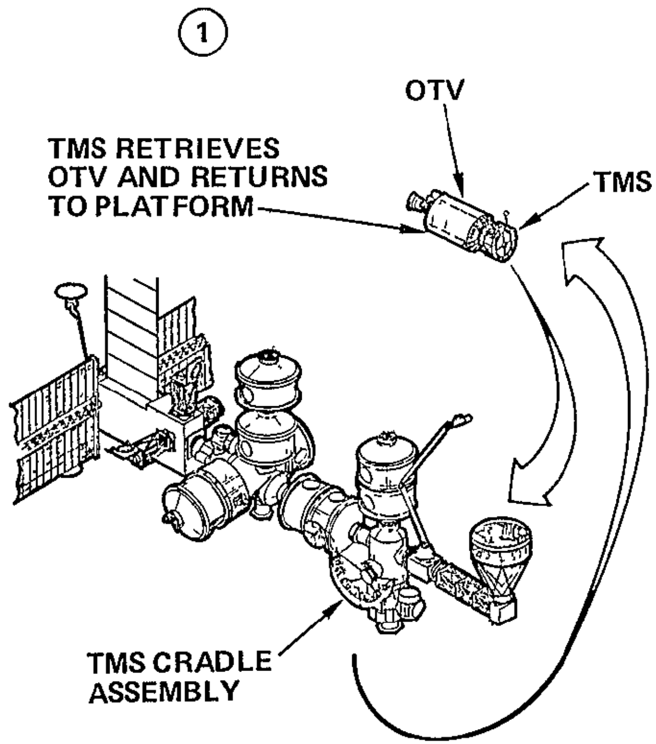
Vertical Rack Available in Module = 650 In.

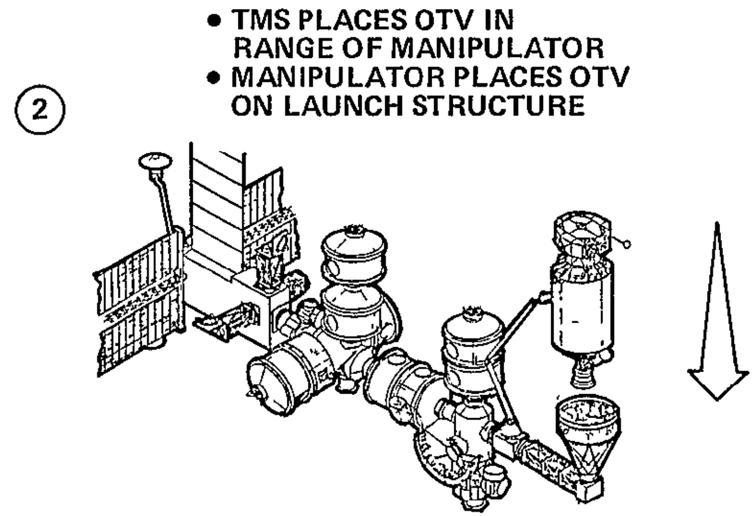
Therefore, OTV Equipment Requires Approximately 5 Racks or One Side of Short Module

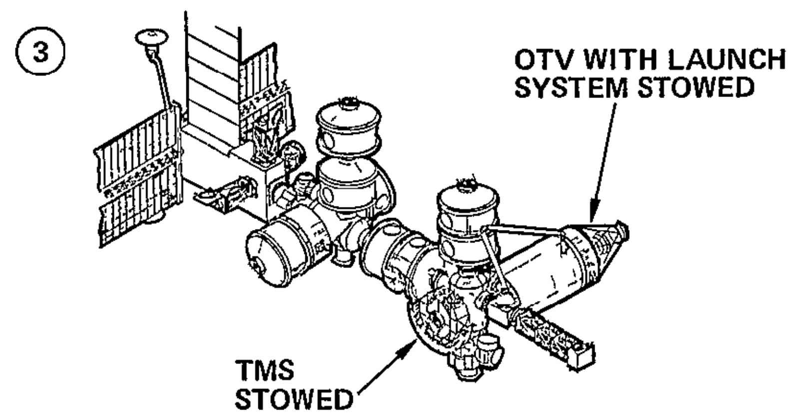
Total Height of 20 In. Racks Reqd = 240 In.
+60 Contingency
300 In.

VFO681

OTV OPERATING SCENARIO (RETURN SEQUENCE)







OTV RESUPPLY CONSIDERATIONS

Resupply Options

- Tanker Stays in Orbiter EVA Hookup Transfer Lines-Pressure Transfer
- ✓ Favored — Tanker Removed and Berthed to Platform-Pressure Transfer Through Berthing Interface
- Interchange OTVs

Transfer Umbilical

- OTV Design Same As Used in Orbiter For Ground Loading
- Tanker Location To Minimize Line Lengths
- OTV and Tanker Side of Interface Passive
- Active Portion Built Into Platform Design

Propellant Transfer

- Transfer Technique Depends on Type of Fuel Selected
- Cryogenic Fuel Will Require Special Passive Screen Devices to Accomplish Transfer
- Energy Addition, Depressurization, and Positive Expulsion Are Primary Transfer Considerations

Propellant Type

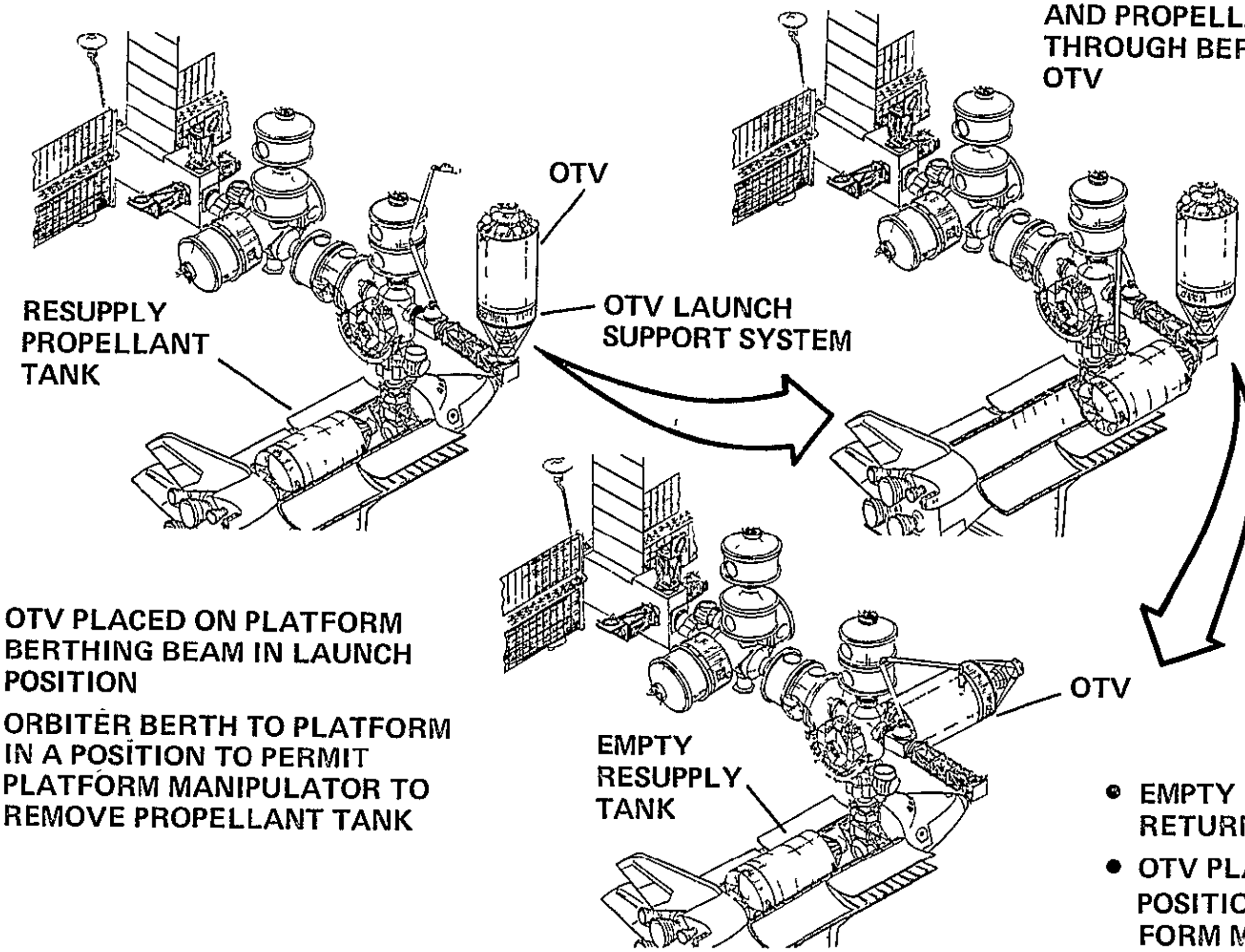
- Cryogen
  - Large Residual May Be Required
  - Chilldown Losses
  - Settling Force May Be Required
  - Losses Due to Extended On-Orbit Storage
- Storable
  - MMH/N_2O_4, ETC.
  - Transferable With Minimal Losses
  - State-of-the-Art Expulsion Technique

Problem Areas

- Propellant Selection
- Transfer System
- System Weight
- On-Orbit Handling of Large Stages

OTV OPERATING SCENARIO
(PROPELLANT RESUPPLY SEQUENCE)

VFO726



- OTV PLACED ON PLATFORM BERTHING BEAM IN LAUNCH POSITION
- ORBITER BERTH TO PLATFORM IN A POSITION TO PERMIT PLATFORM MANIPULATOR TO REMOVE PROPELLANT TANK

- PROPELLANT TANK REMOVED FROM ORBITER AND BERTHED TO PLATFORM BEAM
- RESUPPLY TANK PRESSURIZED AND PROPELLANT TRANSFERRED THROUGH BERTHING PORT TO OTV

- EMPTY RESUPPLY TANK RETURNED TO OBITER
- OTV PLACED IN STOWED POSITION USING PLAT-FORM MANIPULATOR

ORBIT-BASED OTV TECHNOLOGY NEEDS

- Propulsion Subsystem Must Include Additional Redundancy to Preclude Failures
- Electrically Powered Propellant Pumps
- Automated System C/O or Self-Checking
- Automated Launch Sequence With Minimum Data Output or Crew Support
- Long-Life OTV Engine and Multiple Reuse Without Refurbishment
- Leakfree Quick Disconnects
- Propellant Transfer
- Long-Term Cryogenic Propellant Storage
- Propellant Mass Gaging (Loading Accuracy)
- Modular Replaceable Units

AGENDA

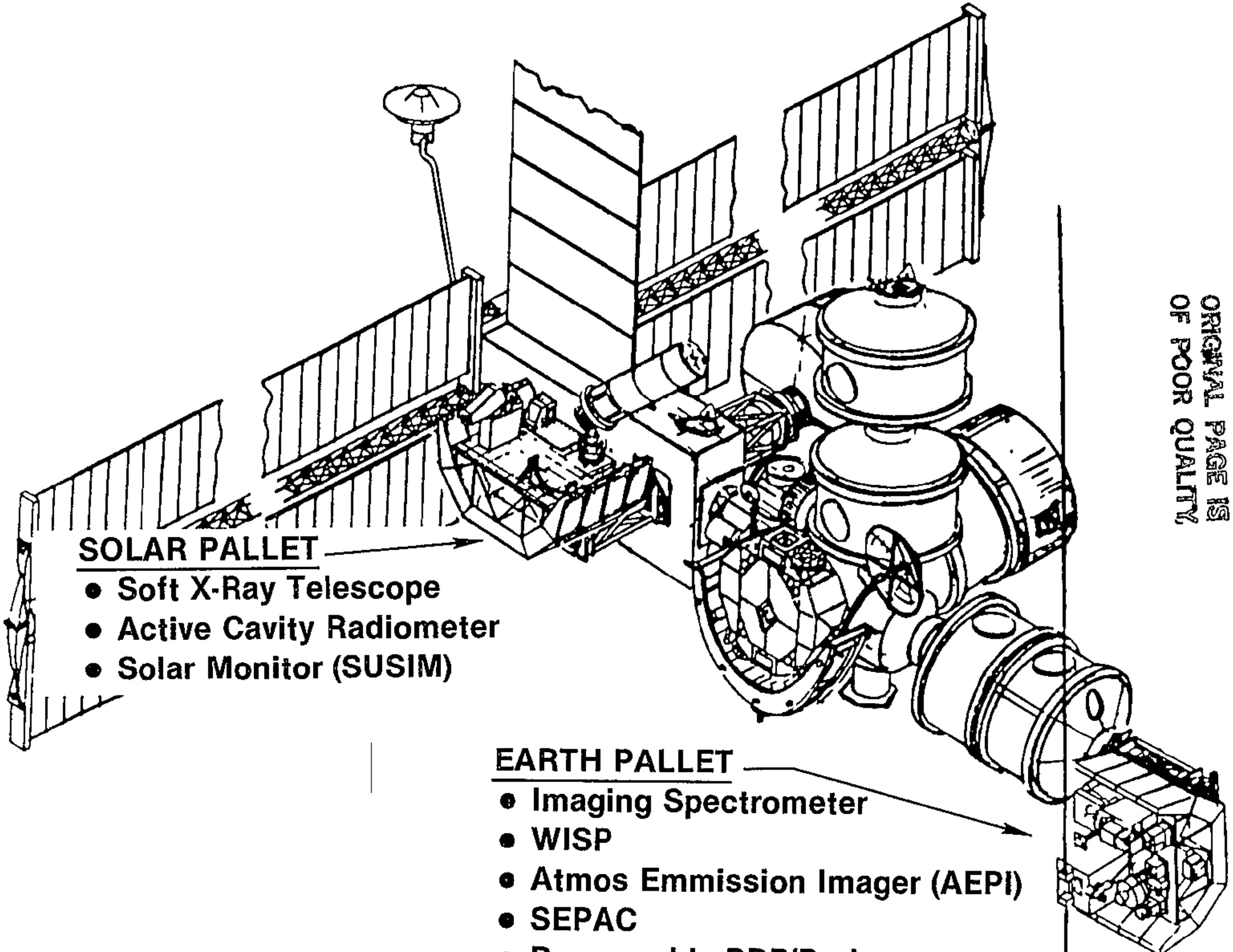
Study Overview	Fritz Runge
Special Unmanned Platform Studies (Task A)	
Manned Platform Concept (Task B)	Fritz Runge
■ Configuration, Structural/Mechanical and Operations	
■ System and Payload Requirements, and Performance	Dave Riel
■ Subsystems, Habitability, and Safety	Bill Nelson
■ Programmatics	Denny Niblo

REQUIREMENTS/PERFORMANCE ANALYSES

- Payload Activities
- Platform System Sizing

VFO 835

MANNED PLATFORM — SOLAR/ TERRESTRIAL PAYLOAD CANDIDATES



SOLAR PALLET
- Soft X-Ray Telescope
- Active Cavity Radiometer
- Solar Monitor (SUSIM)

EARTH PALLET
- Imaging Spectrometer
- WISP
- Atmos Emmission Imager (AEPI)
- SEPAC
- Recoverable PDP/Probes

SOLAR-TERRESTRIAL MANNED PLATFORM PROGRAM

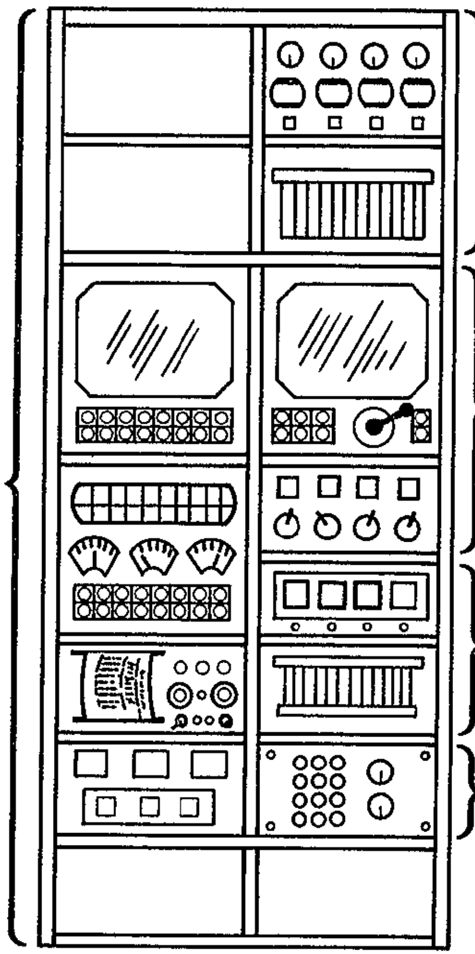
VFO760

SOLAR EXPERIMENTS

- ACTIVE CAVITY RADIOMETER (ACR) (PALLET ONLY)
- SOLAR ULTRAVIOLET SPECTRAL IRRADIANCE MONITOR (SUSIM)
- SOFT X-RAY TELESCOPE

TERRESTRIAL AND MAGNETOSPHERIC EXPERIMENTS

- SPACE EXPERIMENTS WITH PARTICLE ACCELERATION (SEPAC)
- RECOVERAL PLASMA DIAGNOSTIC PACKAGE (RPDP) (PALLET ONLY)
- ATMOSPHERIC EMISSION PHOTOMETRIC IMAGING (AEPI)
- WAVES IN SPACE PLASMA (WISP)



CREW ACTIVITIES

- ACR – NONE
- SUSIM – NONE
- SOFT X-RAY TELESCOPE – POINTING AREA SELECTION AND DATA MONITORING
- SEPAC
  - POINTING CONTROL OF PARTICLE ACCELERATOR
  - BEAM CHARACTERISTIC SELECTION
  - FREE-FLYER CONTROL
  - SENSOR AND DATA MONITORING
- RPDP – NONE
- AEPI – TARGET SELECTION AND POINTING CONTROL
- WISP
  - MEASUREMENT INITIATION
  - POINTING CONTROL
  - DATA MONITORING

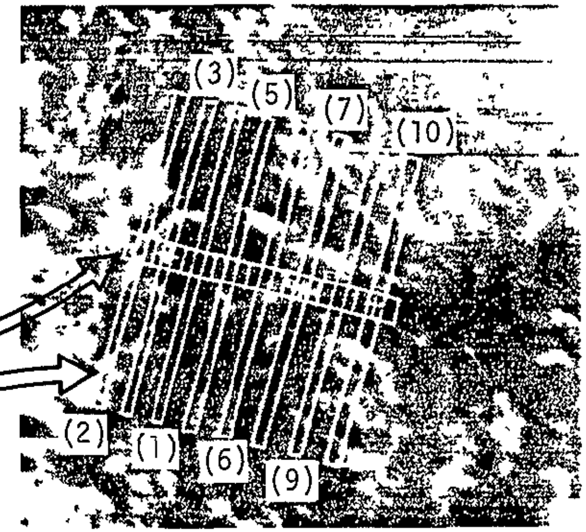
HIGH-VALUE CONTRIBUTION OF ON-ORBIT CREW WITH IMAGING PAYLOADS

VF0419

EXAMPLE DISCIPLINE	SOLAR PHYSICS	
SELECTED EXPERIMENTS	H-ALPHA GRATING	XUV SPECTROGRAPH SLIT
FIELD OF VIEW ARC MIN	16–35	56
SPOT VIEW ARC SEC	5 x 5	2 x 60

CASE 1

CASE 2



(2 ARC SEC = 1400 kM ON SUN)

BASIC ROLES OF CREW

- EXECUTE EXPERIMENT MODE SEQUENCES AND MONITOR IMAGES
- INTERPRET/CORRELATE PHENOMENA (VIDEO, DIGITAL, AND AUDIO FLARE ALARM INPUTS)
- CONTROL FINE POINTING IN REAL TIME PER INTEREST

CASE 1

- MANUALLY SCAN GRATING BACK AND FORTH ACROSS H-ALPHA EMISSION POINTS AND WATCH XUV DETECTOR TO LOCATE AND POINT AT SPOTS OF PEAK EMISSIONS

CASE 2

- STEP 2 x 60 ARC MIN SLIT ACROSS IMAGE IN 2- TO 5-ARC MIN STEPS CHROMOSPHERIC NETWORK CELLS DIFFICULT TO RECOGNIZE (DARK AND BUSHY CLUMPS) (10 ARC SEC BOUNDARIES)
- CREW SELECTS PROMINENT, NOT DISSIPATING CELL
- ZOOM VIEW SO THAT EYE CAN AVERAGE OUT IRREGULARITIES
- POINT AT CELL BOUNDARY AND ZOOM WITHOUT LOSING LOCATION
- CREW ENHANCES POSSIBILITY OF CATCHING FLARE ONSET AND CORONAL TRANSIENTS WHICH OFTEN FOLLOW FLARES

CONTINGENCY ROLL OF CREW

- PLAN SCHEDULE AND RESCHEDULE IN REAL TIME (PRIMARY, SECONDARY, NEW INTERESTS)

LIFE SCIENCES MANNED PLATFORM PROGRAM
(EXAMPLE 90-DAY ACTIVITY)

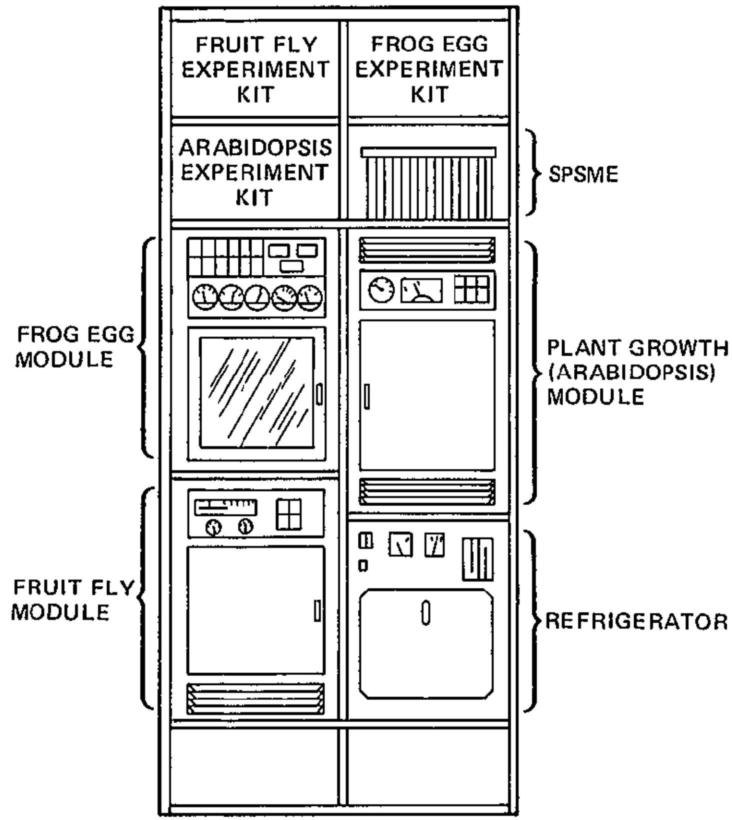
VFO676

SPACE BIOLOGY EXPERIMENTS

- EFFECTS OF WEIGHTLESSNESS ON FROG EGG FERTILIZATION AND LARVAL MORPHOGENESIS (90-DAY CYCLE)
- ARABIDOPSIS PLANT GROWTH, DEVELOPMENT, AND HEREDITY IN ZERO G (21-DAY CYCLE)
- DROSOPHILA (FRUIT FLY) BEHAVIOR AND LIFE CYCLE PHENOMENA IN ZERO G (15-DAY CYCLE)

SELECTION CRITERIA

- HABITAT-COMPATIBLE
- TWO-RACK ALLOCATION
- EXTENSIVE CREW INVOLVEMENT
- MODERATE INVESTMENT



CREW ACTIVITIES

- HARVEST FROG EGGS AND SPERM
- MIX EGGS AND SPERM IN MODULE CONTAINERS
- ENSURE PHOTOGRAPHY AND SPECIMEN FIXING AT PRESCRIBED INTERVALS
- HARVEST ARABIDOPSIS SEEDS AND PLANT IN AGAR MEDIA
- PRESERVE MATURE PLANT PARTS AS PRESCRIBED
- ENSURE PLANT MODULE OPERATION AND ENVIRONMENT CONTROL
- MAINTAIN DROSOPHILA COLONY
- SEPARATE MALE/FEMALE FLIES
- OBSERVE FOR MUTATIONS
- MONITOR DROSOPHILA BEHAVIOR
- COUNT EGG BATCHES
- MAINTAIN MORTALITY RECORDS
- ENSURE OPERATION OF DROSOPHILA MODULE

VFO761

EXPERIMENT ACTIVITY TIMELINES

SOLAR — TERRESTRIAL EXPERIMENTS (PAYLOAD CREWMAN 1)

Experiment Period	A	B	C	D	E
		2 Hr	1 Hr	3 Hr	2 Hr

A — Soft X-Ray Telescope Target Area Selection and Pointing
B — SEPAC Atmospheric Perturbation and Measurement
C — AEPI Pointing and Measurement of Selected Atmospheric Phenomena
D — SEPAC Magnetospheric Measurements Using Sensor Receivers on Free-Flyer
E — WISP Measurements: Initiation, Pointing Control, and Data Monitoring

LIFE SCIENCES EXPERIMENTS (PAYLOAD CREWMAN 2)

Experiment Period	F	G	H	I

F — Frog Egg Experiment Data Collection
G — Drosophila Colony Maintenance
H — Arabidopsis Seed Harvesting and Replanting
I — Drosophila Experiment Activities

EXPERIMENT ACTIVITY TIMELINES

LIFE SCIENCES EXPERIMENTS

1 Hr

Period F, Earth Equivalent Time 8:00 am to 9:00 am

Frog Egg Experiment Data Collection

- Check Experiment Module Temperature, O_2 and CO_2 Levels
- Check Adherence to Fixative Injection Schedule
- Check No. of Exposed Frames in Time-Lapse Photography — Compare With Schedule
- Remove Container Holding Most Recently Fixed Specimen — Examine Progress and Development With Hand Lens
- Record Data

2 Hrs

Period G, Earth Equivalent Time — 10:00 am to 12:00 Noon

Drosophila Colony Maintenance

- Check Displays For Automatically Controlled Temperature and Humidity
- Check Each Drosophila — Containing Capsule in Module
  - — Examine For Amount of Yeast Growth — Reinnoculate As Necessary
  - — Note Newly Deposited Egg Batches and Record Capsule Number
  - — Note Occurence of Dead Flies — Record No. and Capsule
- Record Data

2 Hr

Period H, Earth Equivalent Time — 1:00 pm to 3:00 pm

Arabidopsis Seed Harvesting and Replanting

- Remove Arabidopsis Experiment Kit From Storage and Setup on Workbench
- Remove Arabidopsis Growth Tubes From Refrigerator and Allow to Warm
- Remove, Separately, Arabidopsis Plants From Experiment Module
- Harvest Seeds, Replant Some in New Tubes, and Package Remainder For Return
- Label Seed-Containing Tubes and Return to Experiment Module
- Examine Mature Plants For Abnormalities — Record Observations
- Remove Specified Plant Parts, Preserve, and Prepare For Return. Dispose of Rest of Plant
- Return Kit to Storage and Dispose of Used Tubes

EXPERIMENT ACTIVITY TIMELINES (CONT)

LIFE SCIENCES EXPERIMENTS (CONTINUED)

3 Hr

Period I, Earth Equivalent Time, 4:00 pm — 7:00 pm

Drosophilia Experiment Activities

- Remove Drosophila Experiment Kit From Storage and Setup on Workbench
- Remove Drosophila Container From Experiment Module Previously Noted to Contain Egg Batches
- Anesthetize and Remove Flies
- Using Hand Lens, Separate Males From Females
- Obtain New Containers From Refrigerator
- Place Some Males in One, Females in Another
- Package Remaining Flies For Return
- Using Hand Lens, Count No. of Eggs in Each Egg Batch
- Record Data and Return Containers to Experiment Module

- Remove Containers With Newly Hatched Flies
- Anesthetize Flies, Separate Males From Females, and Examine For Abnormalities
- Place Some Males in One New Container, Females in Another
- Package Remainder For Return

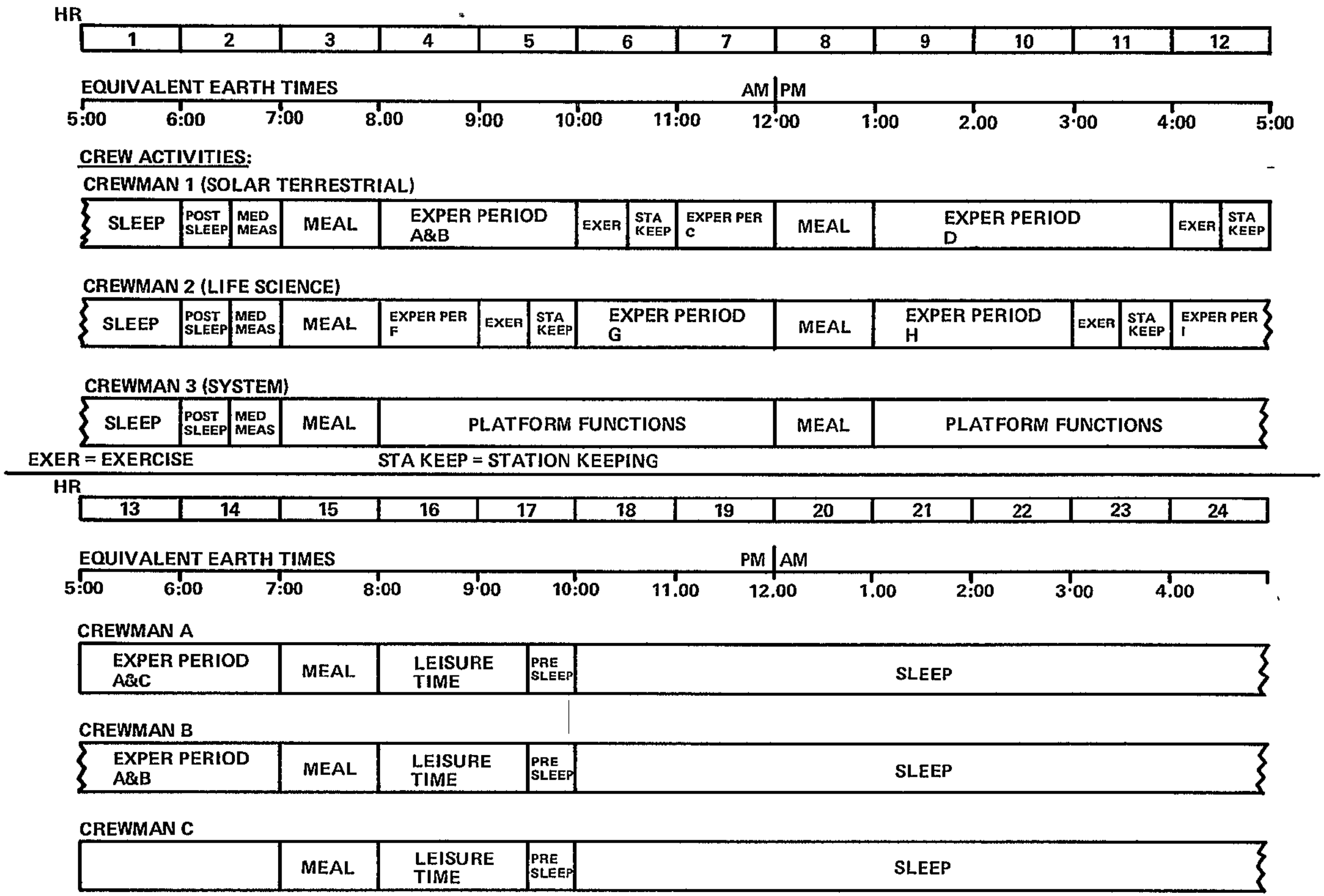
- Remove Containers With Male Flies and Female Flies Which Have Just Reached Maturity
- Anesthetize Flies and Place Some Males and Some Females in New Container
- Allow to Recover and Observe Mating Behavior
- Return Containers to Experiment Module
- Record Observations and Data

- Remove Containers Previously Noted to Contain Dead Flies
- Anesthetize Flies and Remove Dead Specimens
- Package Dead Flies For Return
- Record Longevity Data

- Repack Kit and Return to Storage
- Dispose of All Used Containers and Supplies

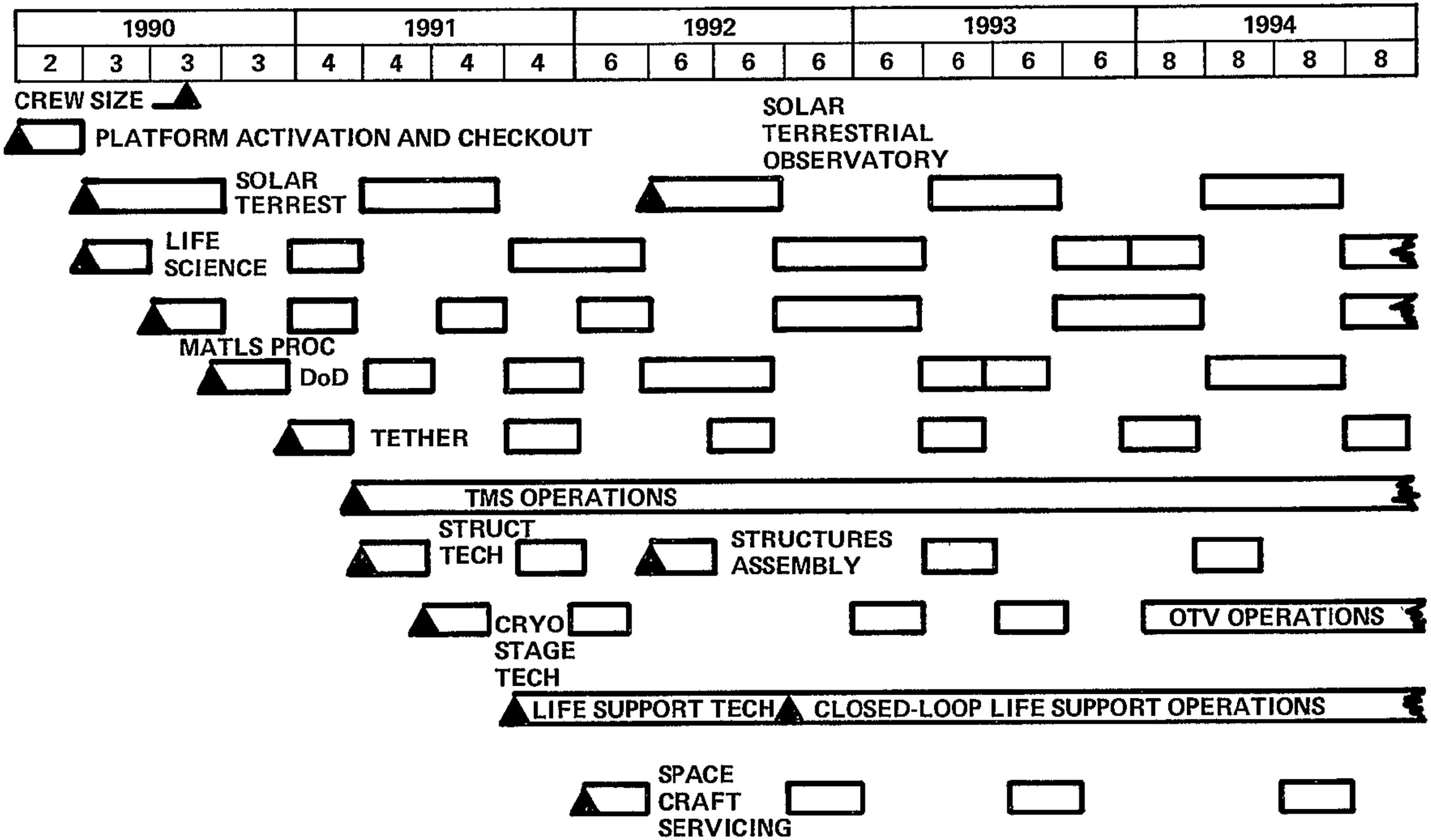
VFO675

CREW TIMELINE — 3 CREWMEN
TYPICAL MISSION DAY



MANNED SPACE PLATFORM (STATION) CREW SIZE AND PAYLOAD UTILIZATION (CANDIDATE PLAN)

VFO789



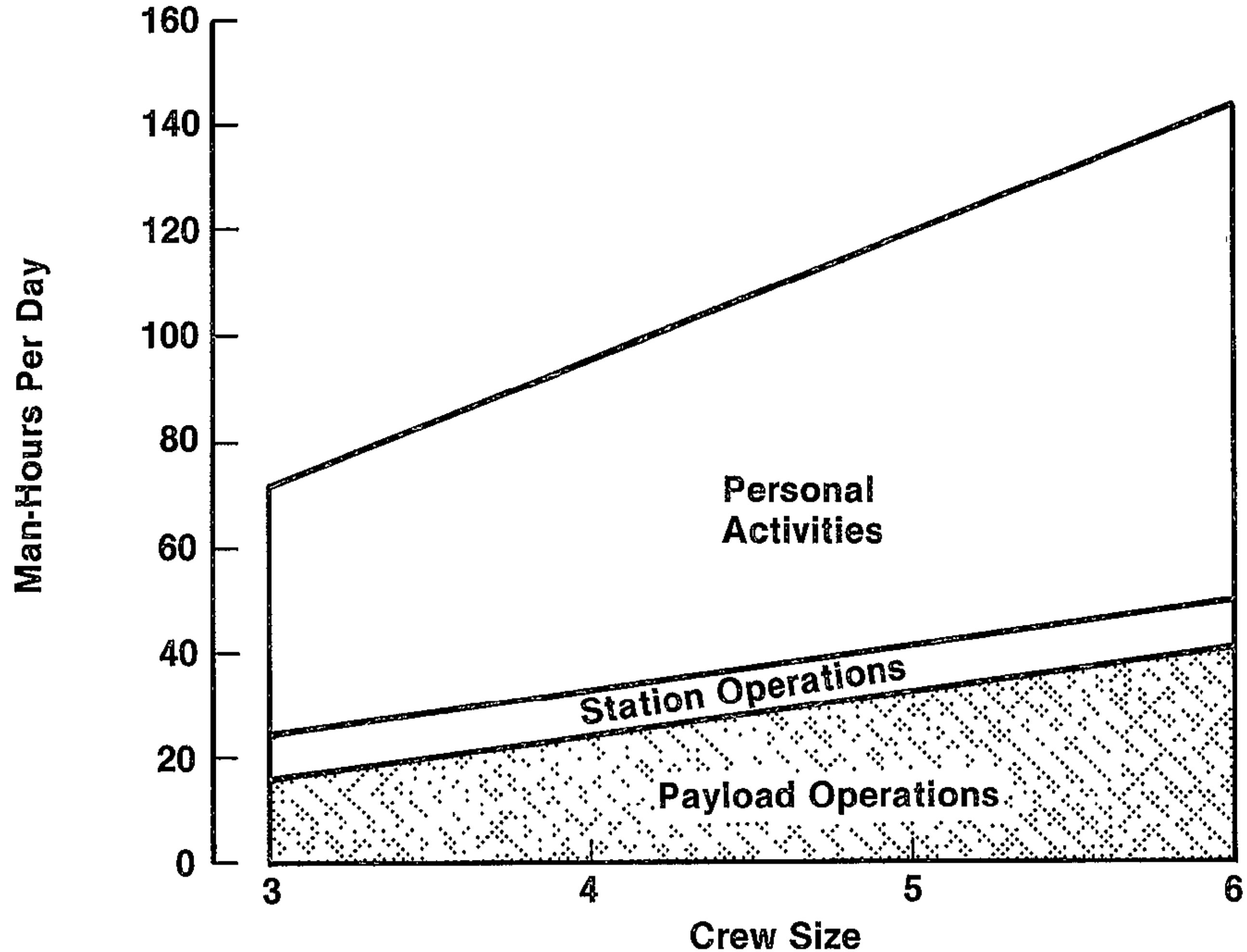
VFO620

CREW SIZE CONSIDERATIONS

- Man-Hour Capabilities
- Skill Mix
- Work-Rest Cycles
- Volume
- Configuration Layout
- Program History
- Logistics
- Cost Factors

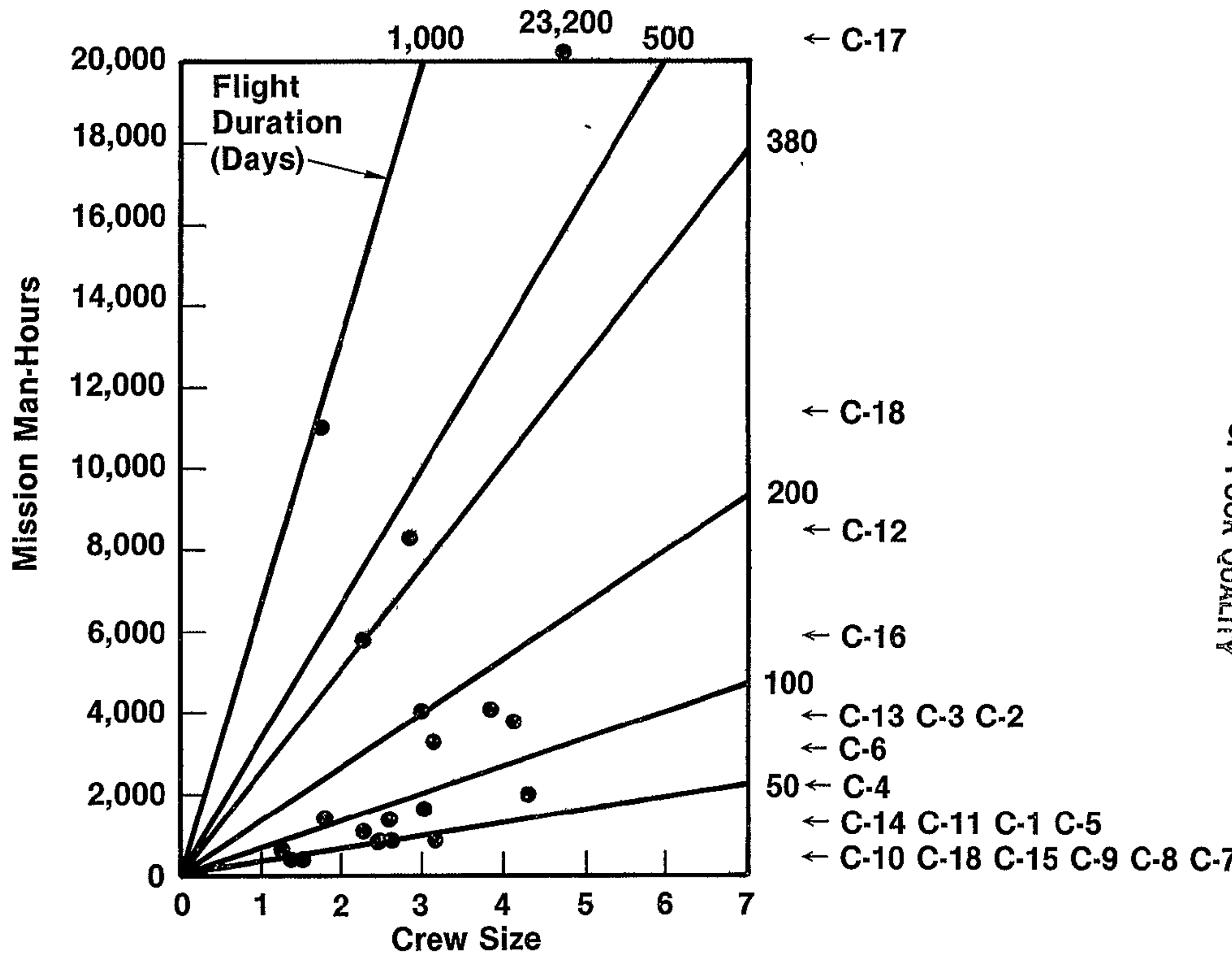
VFO618

MAN-HOUR CAPABILITIES



VFO617

CREW SIZING — MOSC



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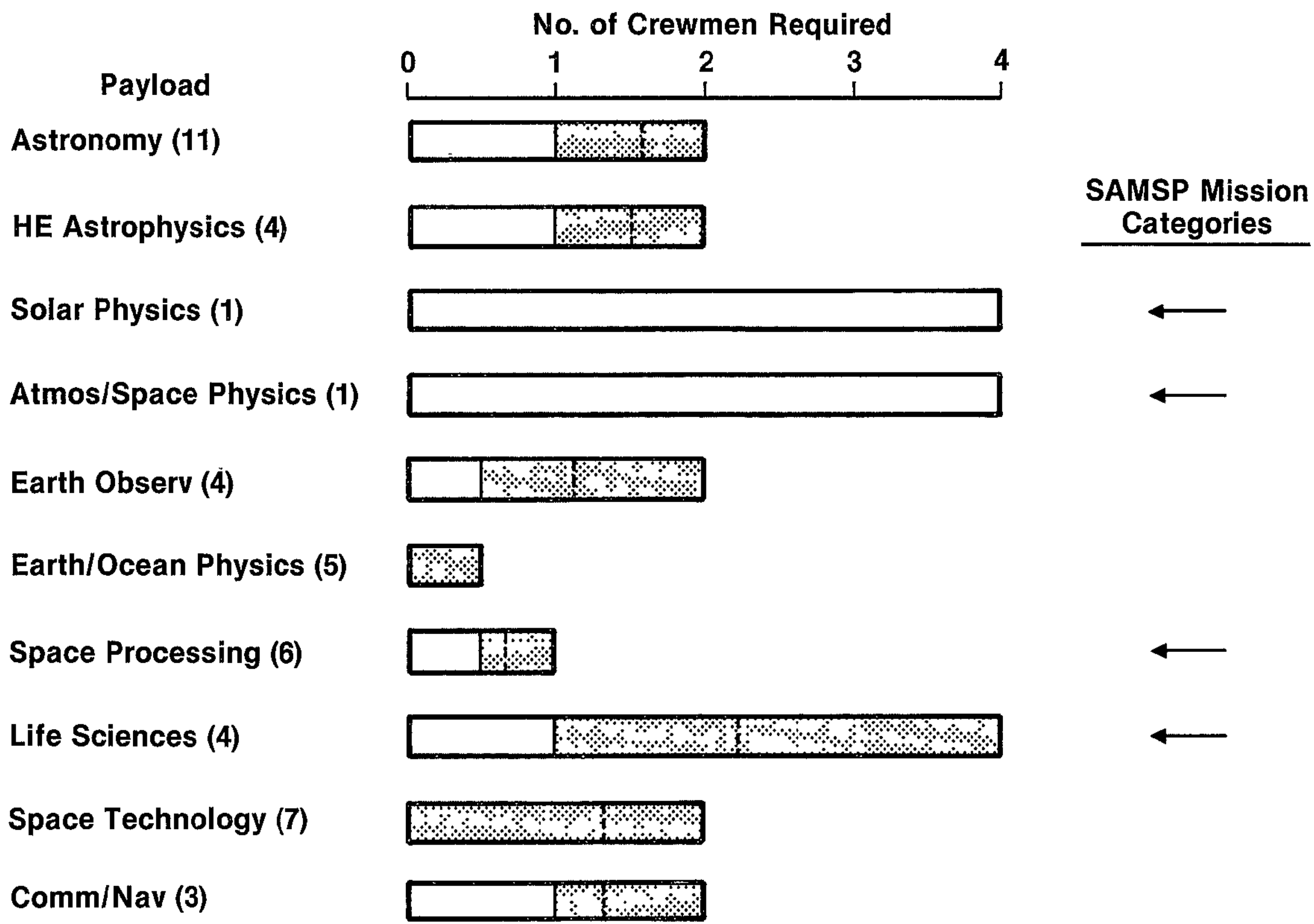
CREW REQUIREMENTS — MOSC STUDY



VFO615

CREW SKILL UTILIZATION

Spacelab Crew Skill Classification

1. Biological Technician
2. Biochemist
3. Medical Doctor
4. Behavioral Scientist
5. Astronomer/Astrophysicist
6. Optical Scientist
7. Electromechanical/Optical Technician
8. Photo Technician/Cartographer
9. Geologist
10. Meteorologist
11. Oceanographer
12. Agronomist
13. Geographer
14. Electronics Engineer
15. Mechanical Engineer
16. Thermodynamicist
17. Metallurgist
18. Chemist
19. Physicist
20. General
21. Biologist
22. Biomedical Technician
23. Crewman

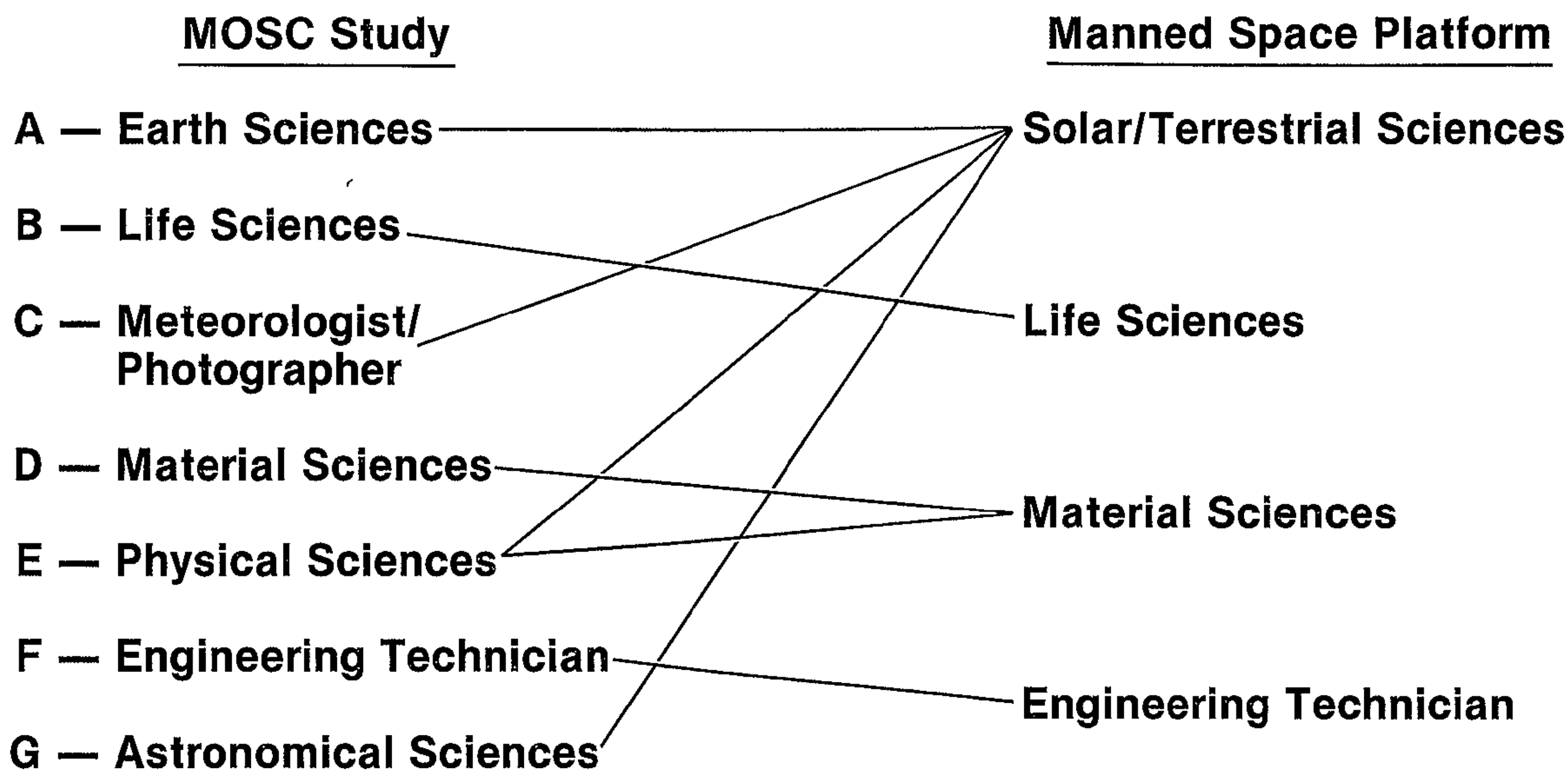
Utiliztion on 50 MOSC Payloads

Electromechanical Technician	29
Astronomer	14
Chemist	12
Oceanographer	8
Electronics Engineer	7
Physicist	7
Geologist	5
Geographer	4
Agronomist	3
Behavioral Scientist	3
Photo Technician	3
Meteorologist	3
Biologist	3
Biochemist	2
Medical Doctor	1

Biological Technician
Optical Scientist
Mechanical Engineer
Thermodynamicist
Metallurgist
General
Crewman

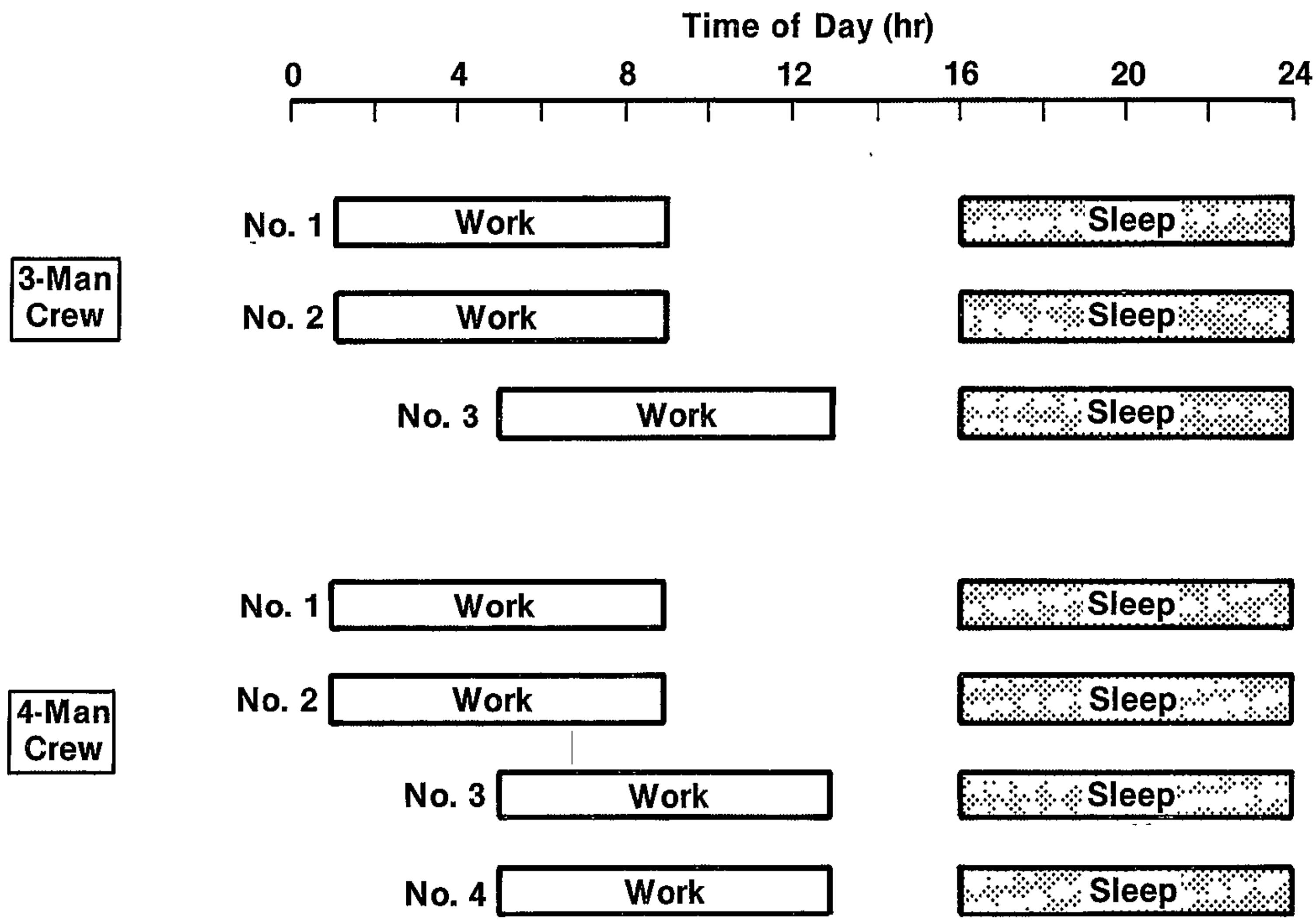
VFO614

COMBINED SKILL SPECIALIST CATEGORIES



VFO613

CREW WORK/REST CYCLES



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FREE VOLUME

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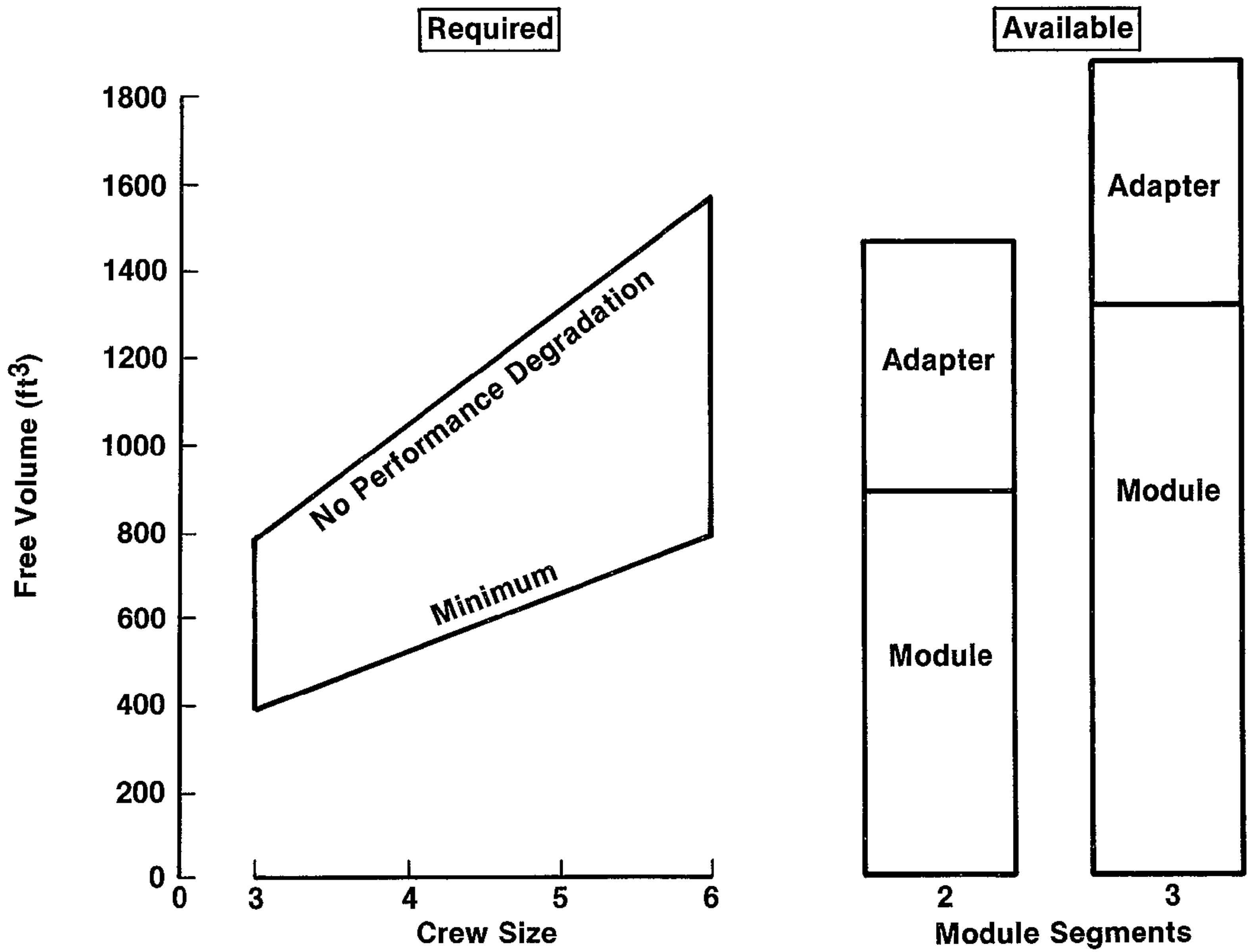
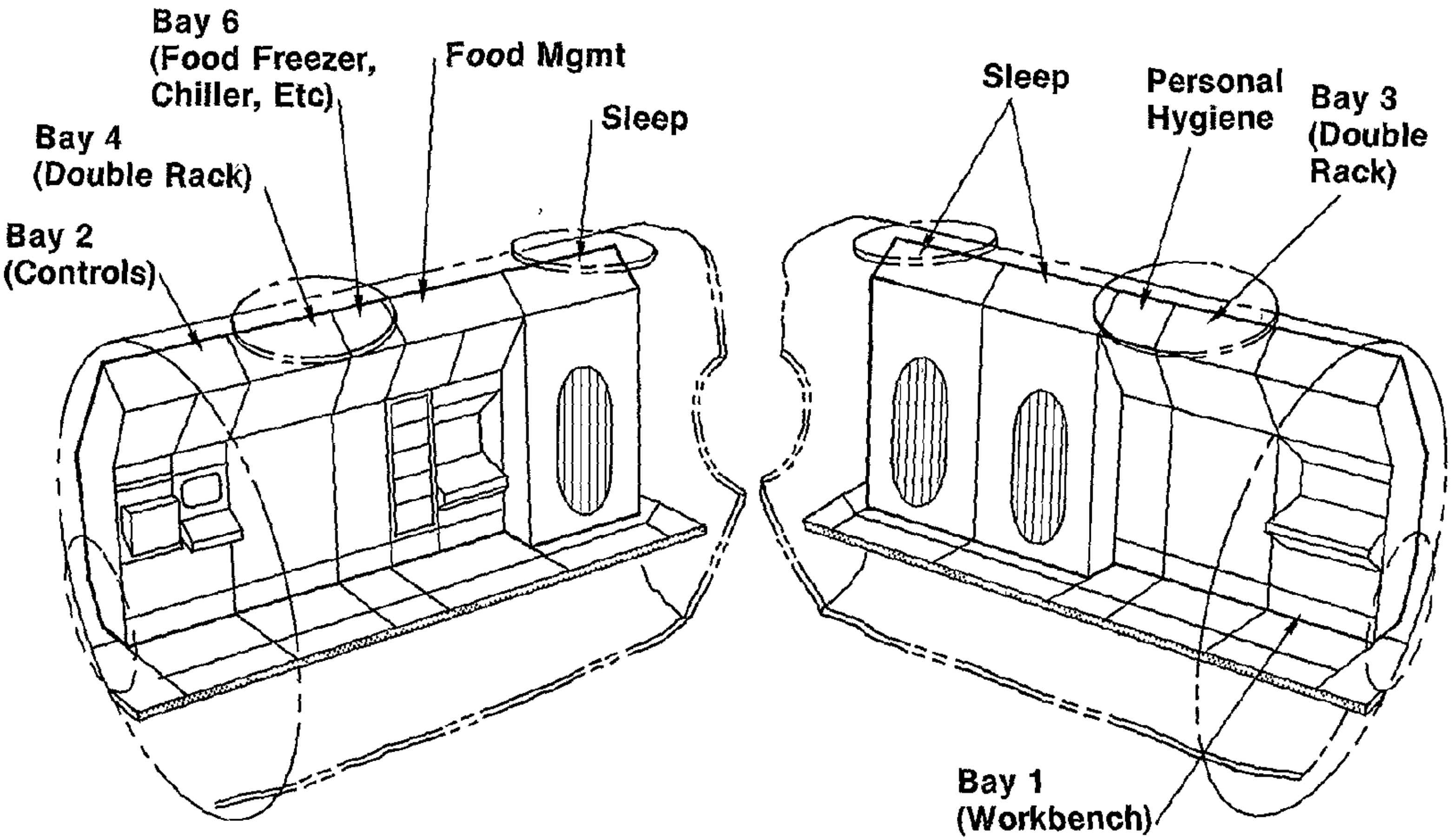


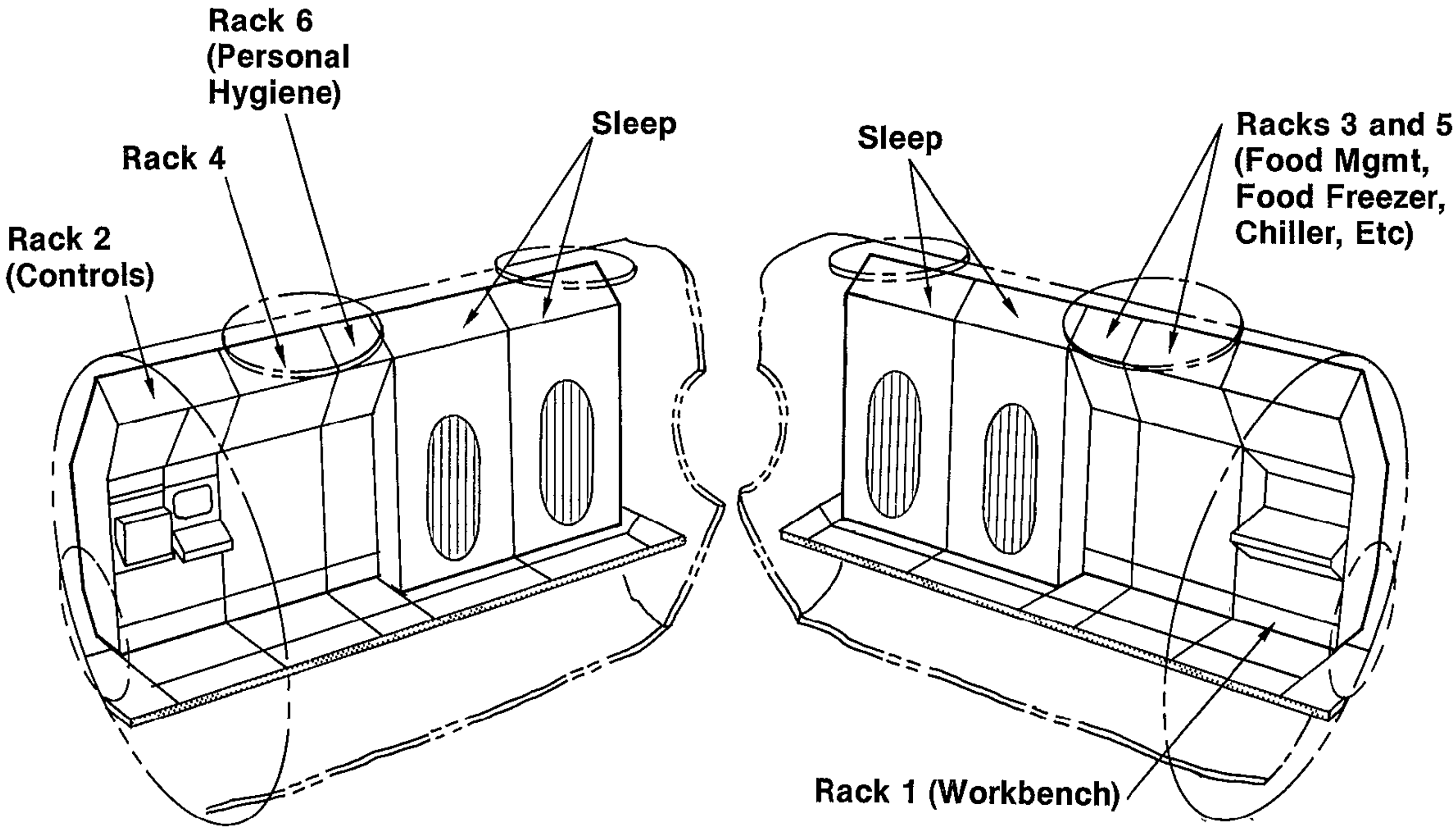
VFO624

3-MAN HABITABILITY MODULE



VFO622

4-MAN HABITABILITY MODULE



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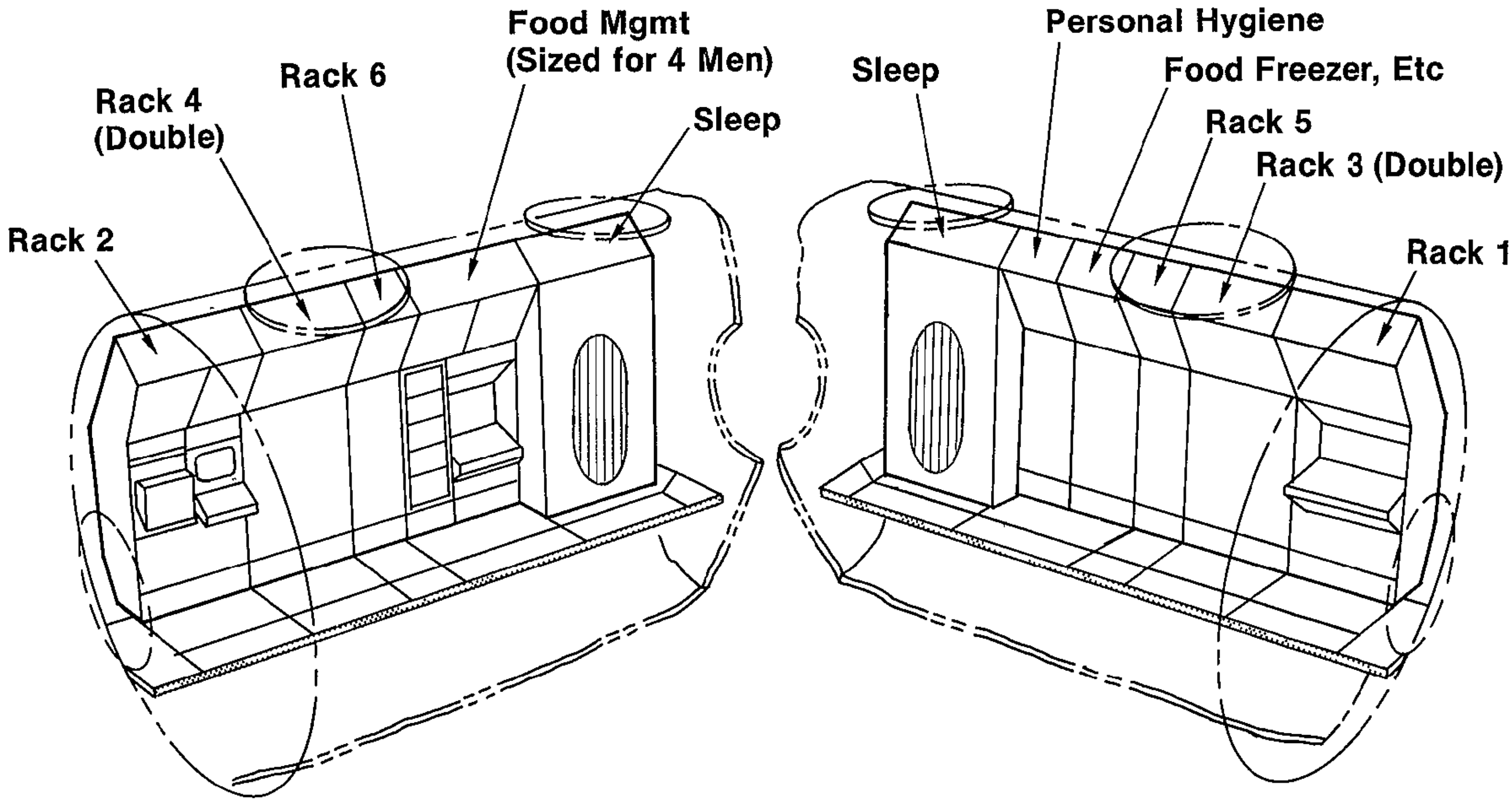
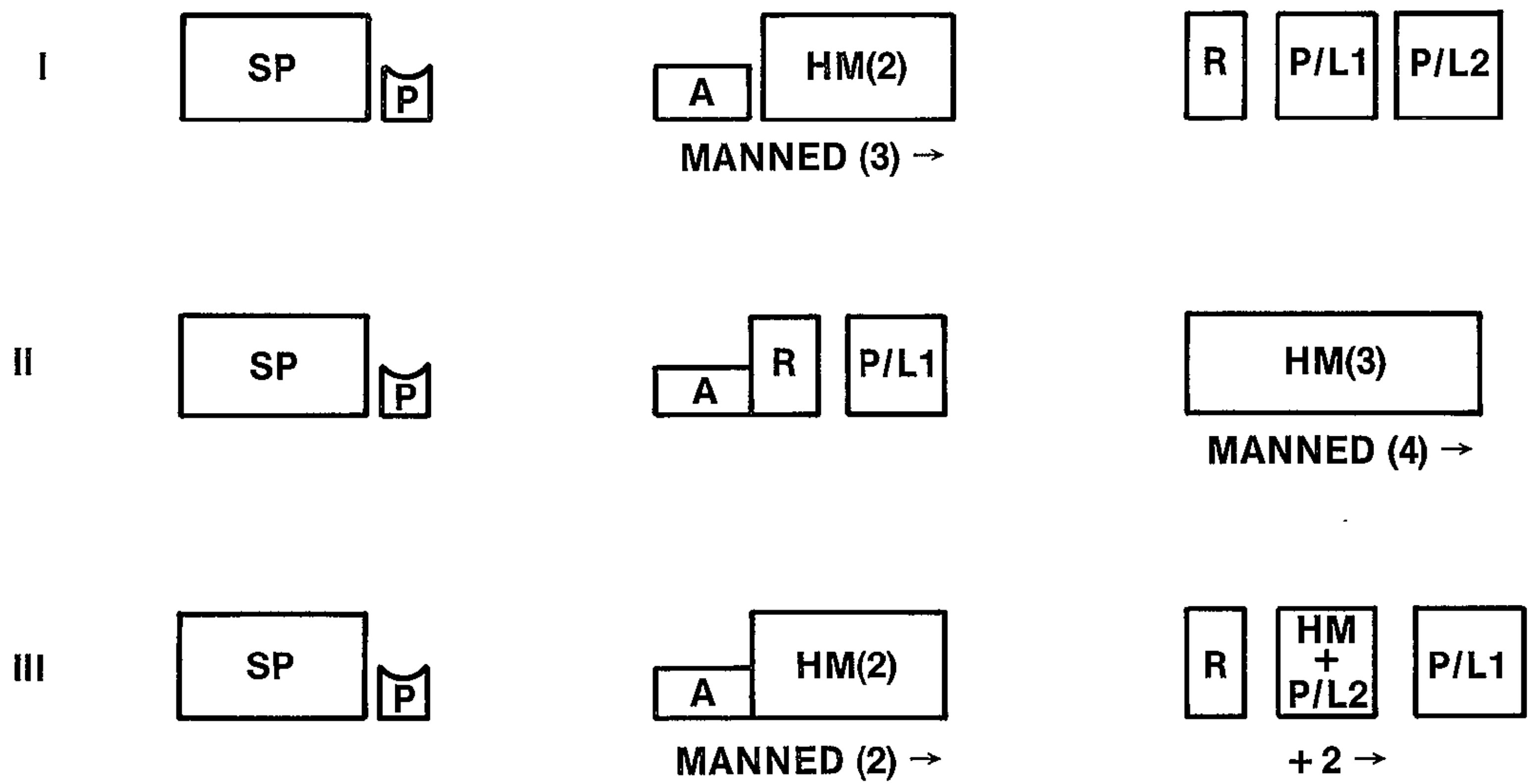
2 + 2-MAN HABITABILITY MODULE



LAUNCH SEQUENCE



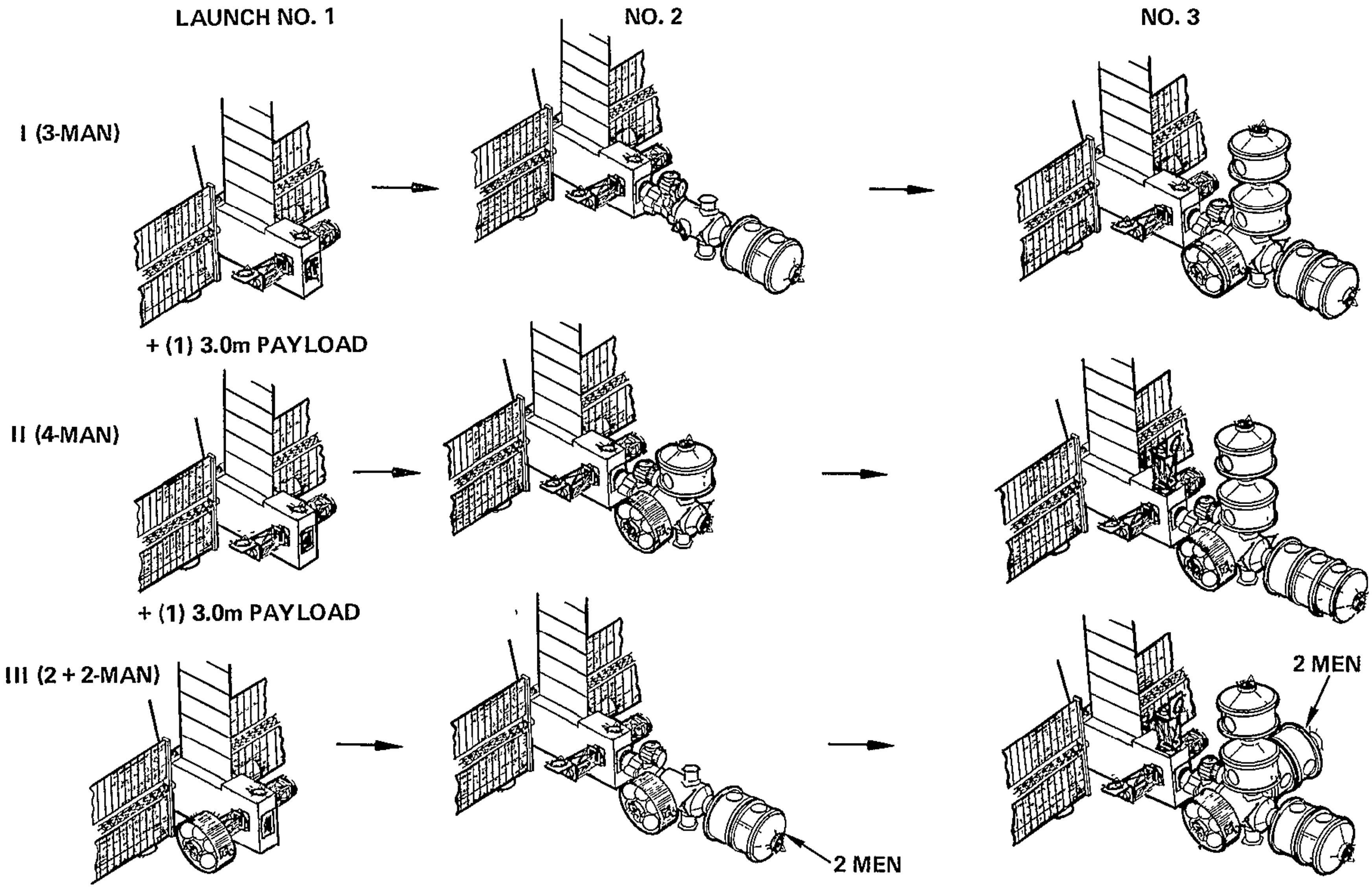
P — Pallet

A — Airlock/Adapter
P/L — Payload

R — Resupply Module
HM — Habitability Module

BUILDUP SEQUENCE

VFO607



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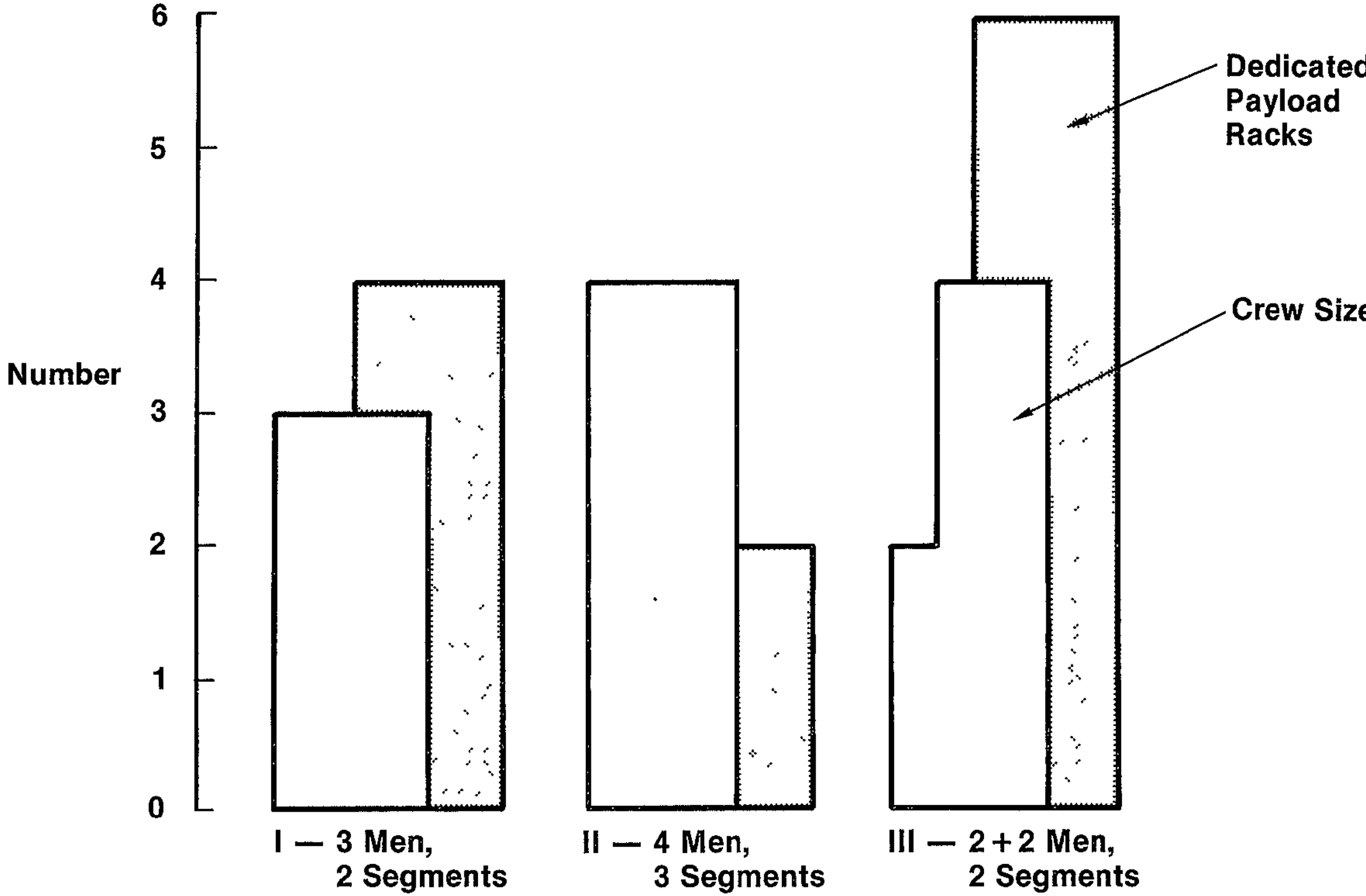
VFO619

PAYLOAD
RACKS/CREW — HABITABILITY MODULE



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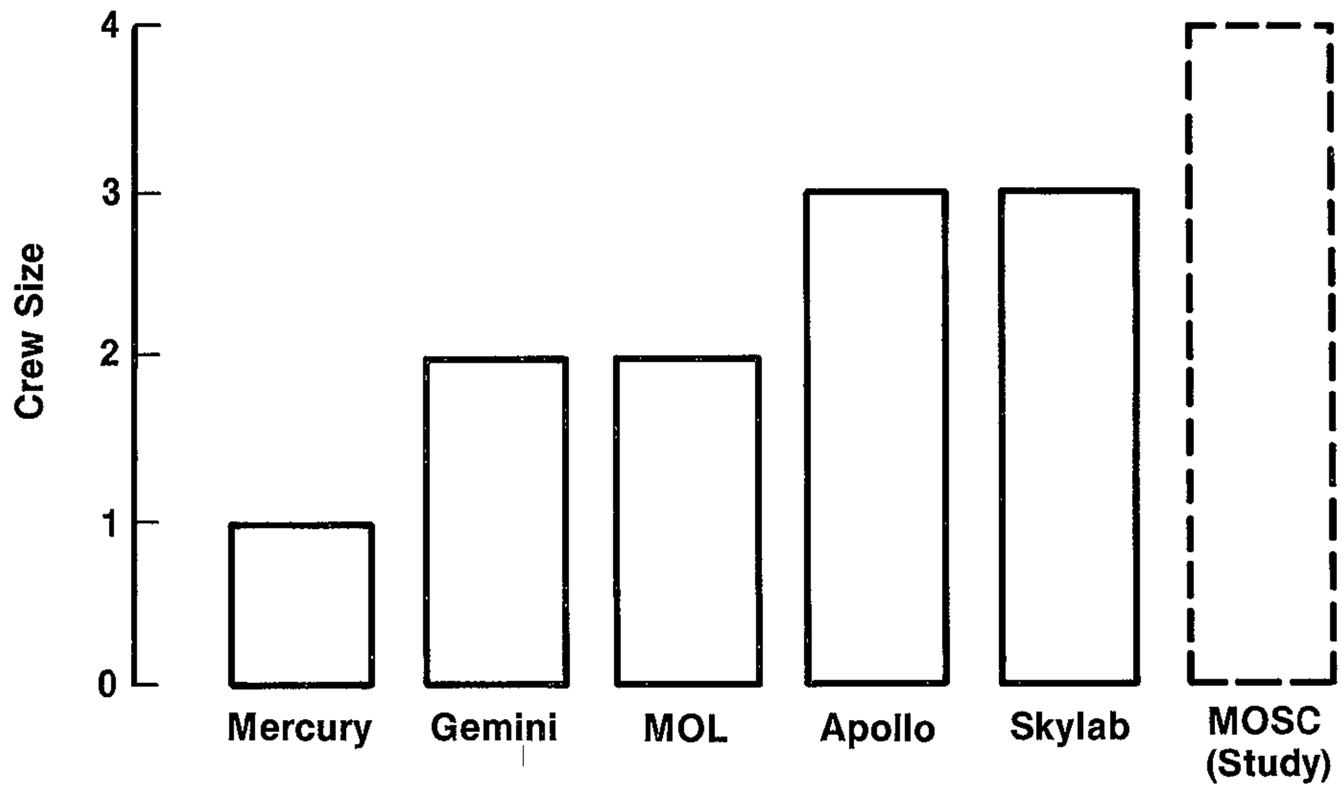
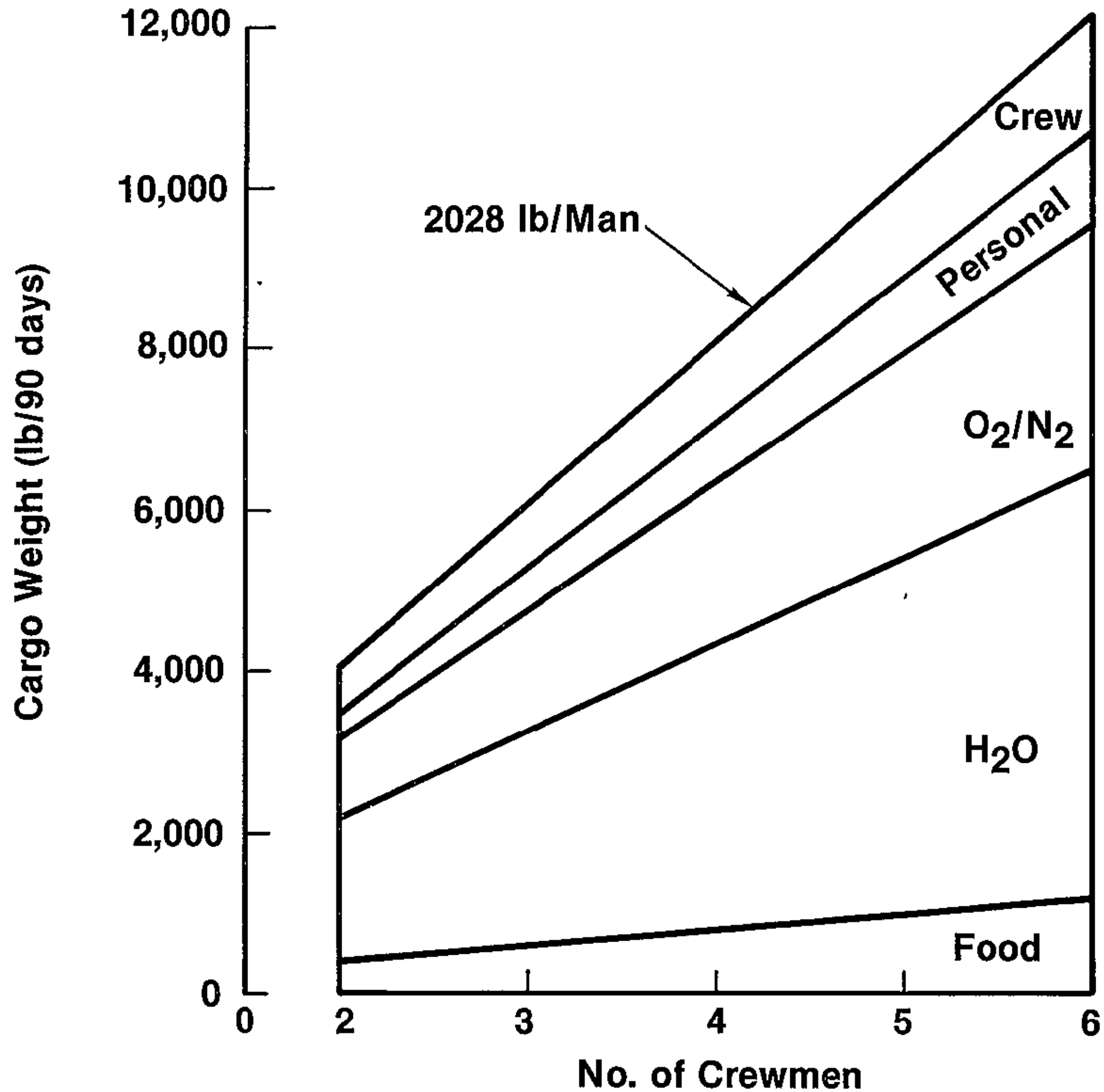
VFO611

CREW SIZE HISTORY



VFO610

CREW-RELATED LOGISTICS



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VFO609

CREW SIZE COST FACTORS

- Training
- Ground Facilities
- Habitation
- Logistics
  - Rotation
  - Resupply

SAMSP CONFIGURATION CANDIDATES

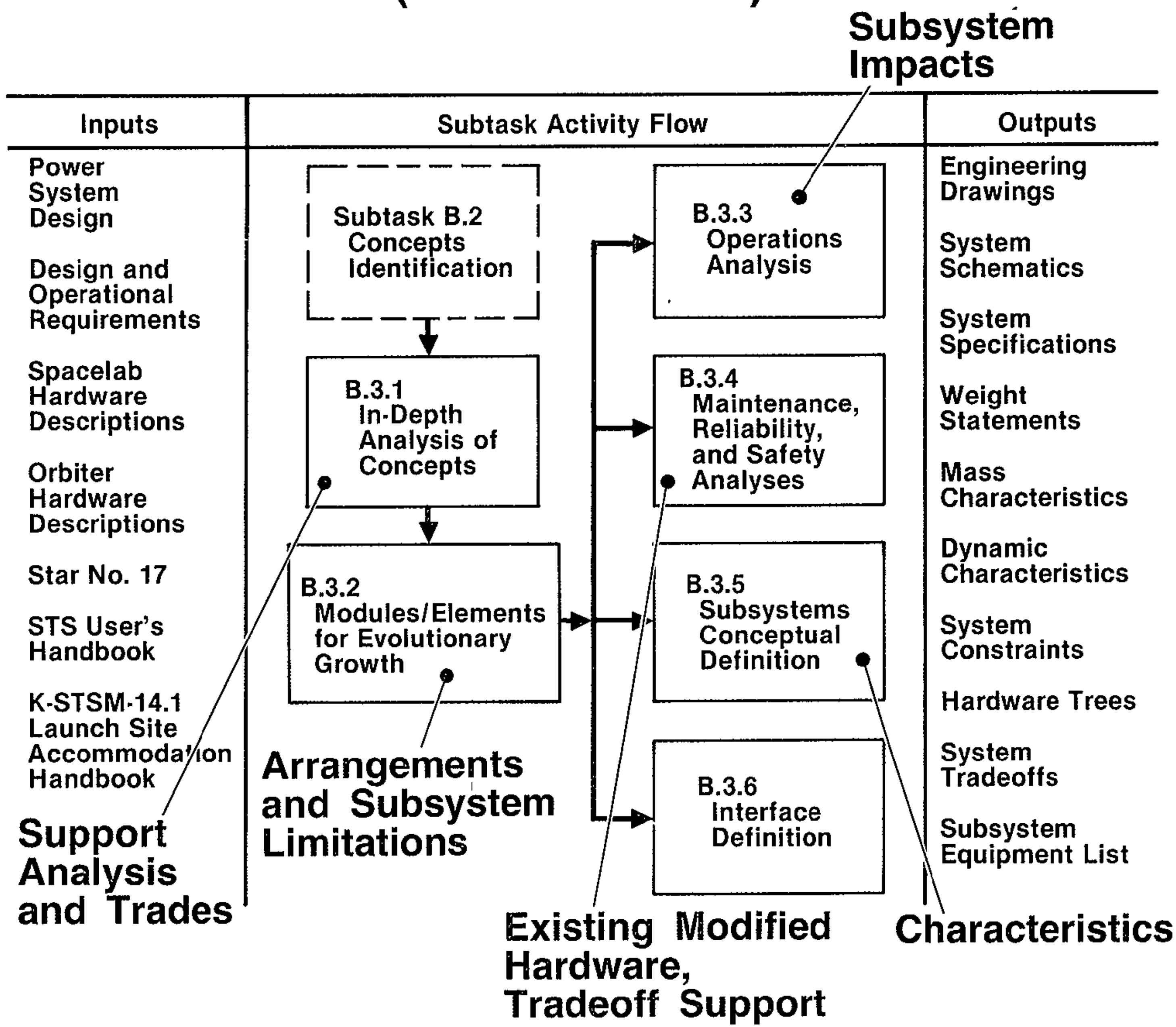
Crew Size	Module Segments	Manning Sequence
3	2	3 → 4 → 6
4	3	4 → 6
2 + 2	2 + 1	2 → 4 → 6

AGENDA

Study Overview	Fritz Runge
Special Unmanned Platform Studies (Task A)	
Manned Platform Concept (Task B)	Fritz Runge
■ Configuration, Structural/Mechanical and Operations	
■ System and Payload Requirements, and Performance	Dave Riel
■ Subsystems, Habitability, and Safety	Bill Nelson
■ Programmatics	Denny Niblo

SUBSYSTEM EFFORT IN SYSTEMS ANALYSIS AND DEFINITION (SUBTASK B.3)

VFK626N



VFO629

REPORT ON VISIT TO ERNO

Spacelab Hardware Delivery

- Engineering Model Nov 1980
- First Flight Unit Nov 1981
- Second Flight Unit May 1982

Spacelab Follow-On Development Program

- Initial Step (Phase A)
  - — Completed in Early 1981
  - — Mission Extension to 20 Days, Experiment Power to 4 kW, Greater Cooling, and CDMS Improvements
  - — 18 to 22 MAU Addition
- Medium-Term Improvement Study (July Start)
  - — Degree of Spacelab Element Autonomy
  - — Reliability and Redundancy Studies
  - — Subsystem Accommodation
  - — Implementation Strategy

ECLS SUBSYSTEM TOPICS

Tradeoffs

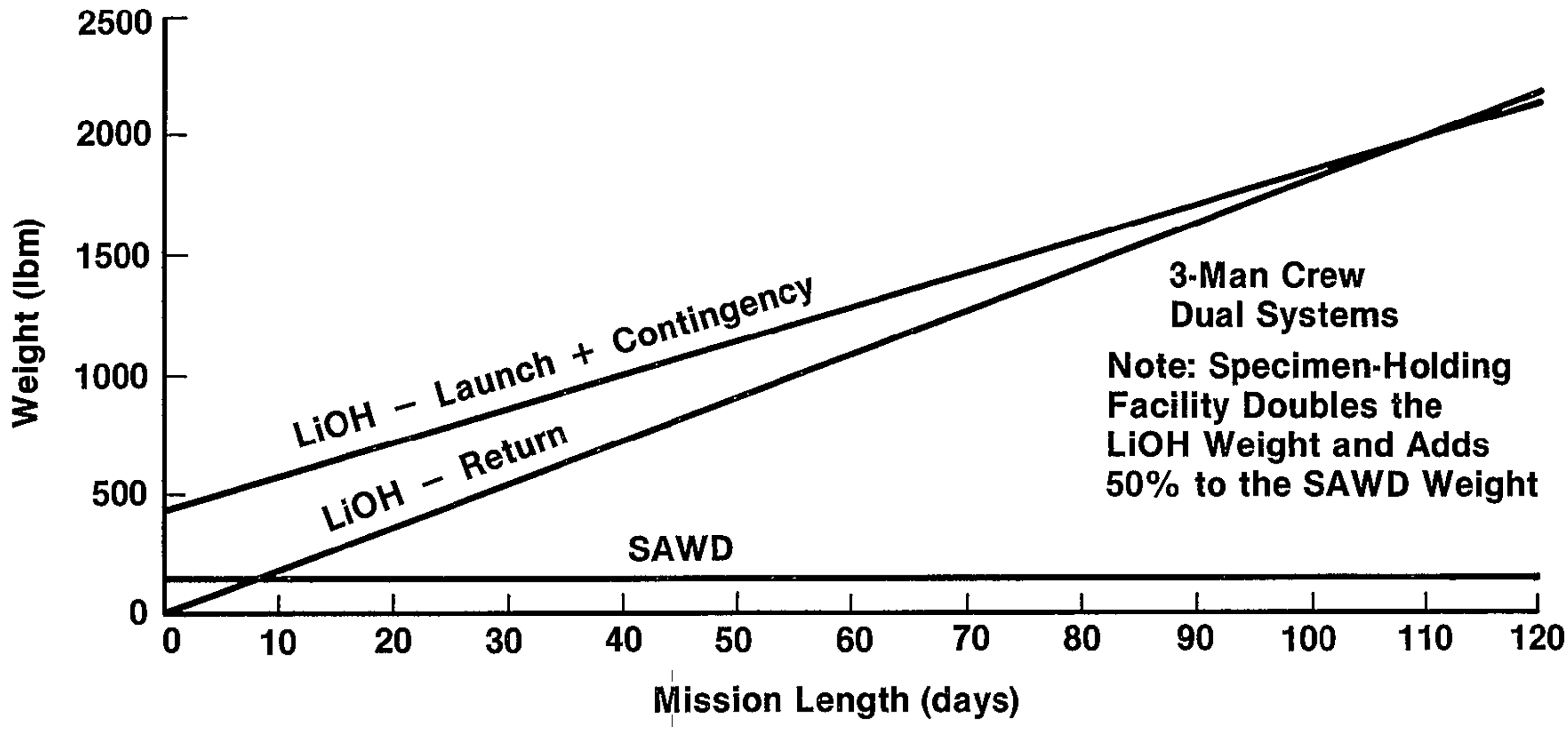
Mass Balances

Equipment Locations

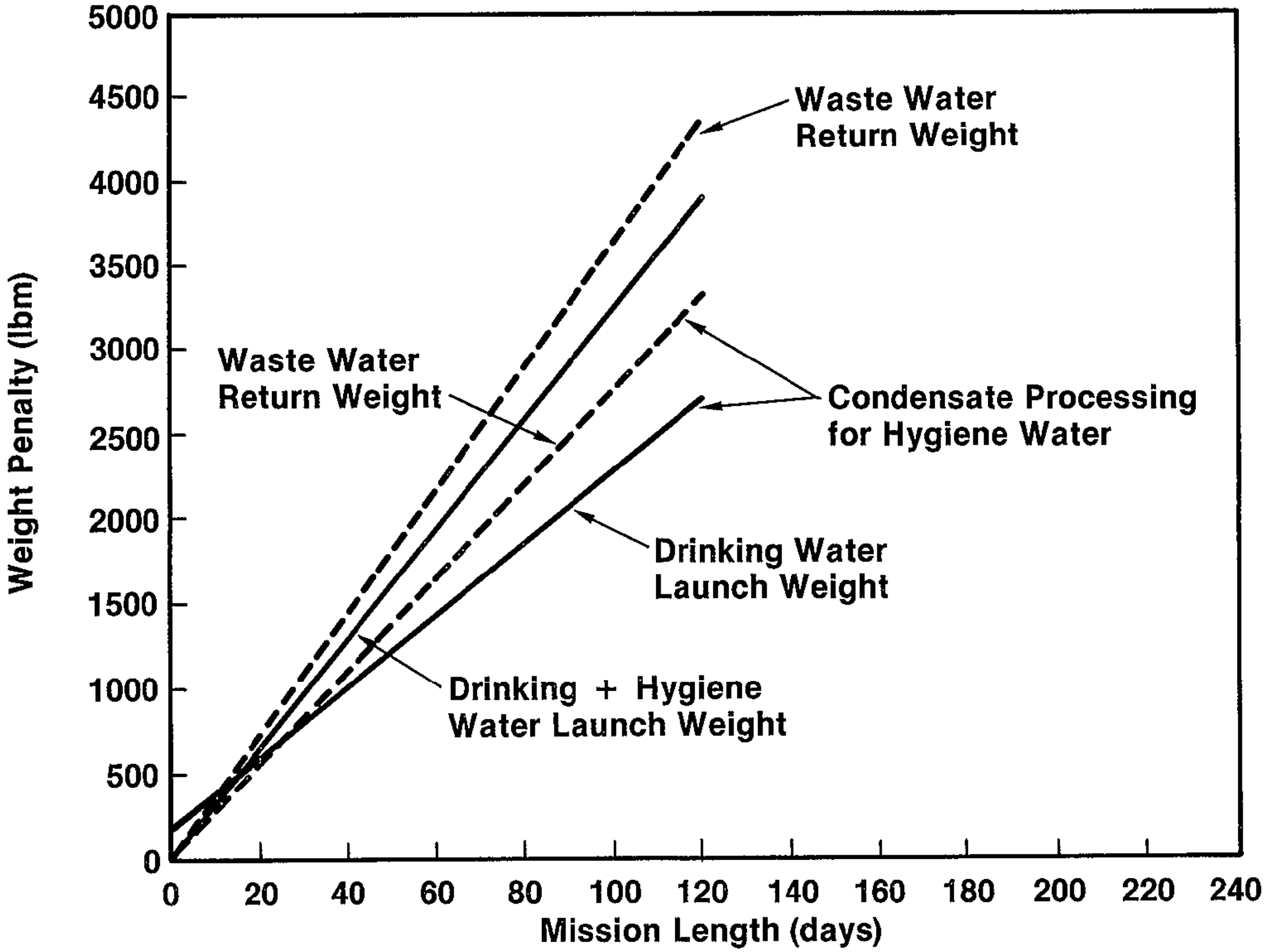
Applicability of Existing Hardware

Approach to Long Life/High Reliability

REGENERABLE CO_2 REMOVAL ADVANTAGE FOR BASIC MSP



CONDENSATE PROCESSING ADVANTAGE FOR BASIC MSP

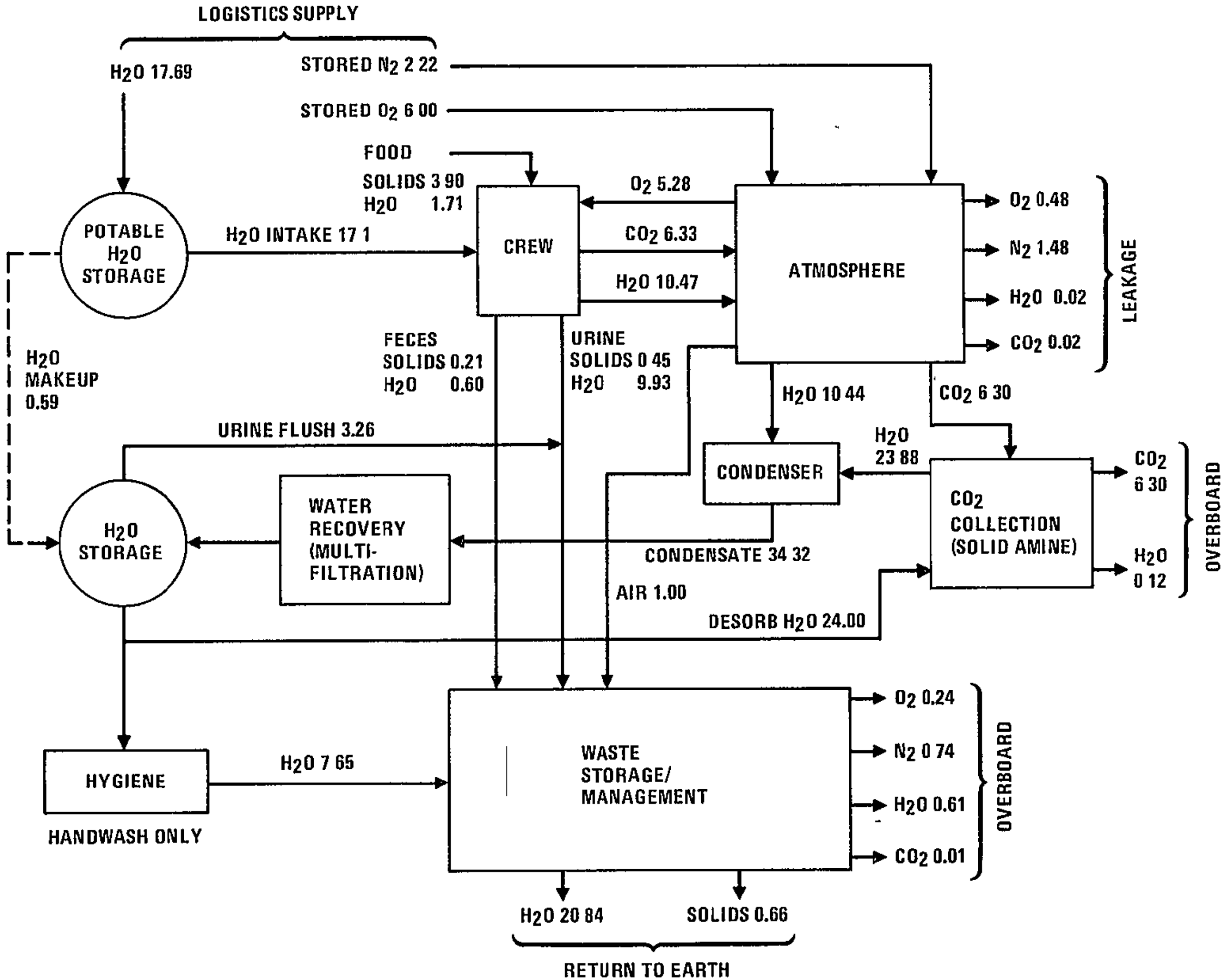


KEY FEATURES OF MSP ECLS

- Regenerable CO_2 Removal
- Partial Water Loop Closing
- Fail-Operational/Fail-Safe
- Maintainable Equipment
- 100% Crew Overload Capability
- No Throwaway Growth Design
- On-Orbit Evaluation of Water Processing
- Optimum Use of Existing Qualified Equipment
- Low Cost and Low Program Risk

VF0644

MSP ECLS BASIC SYSTEM



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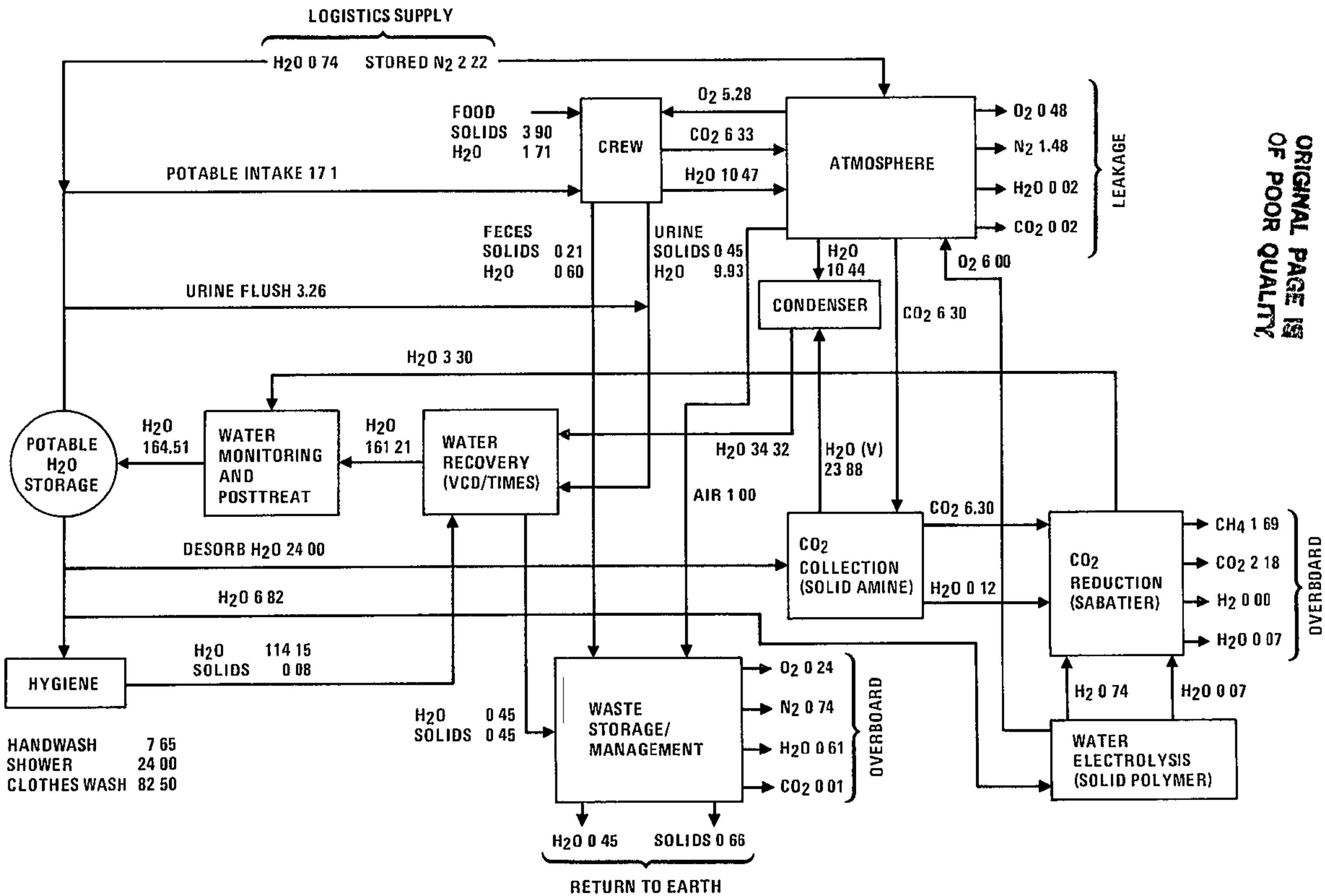
HAMILTON STANDARD

VFO645

MSP ECLS GROWTH SYSTEM



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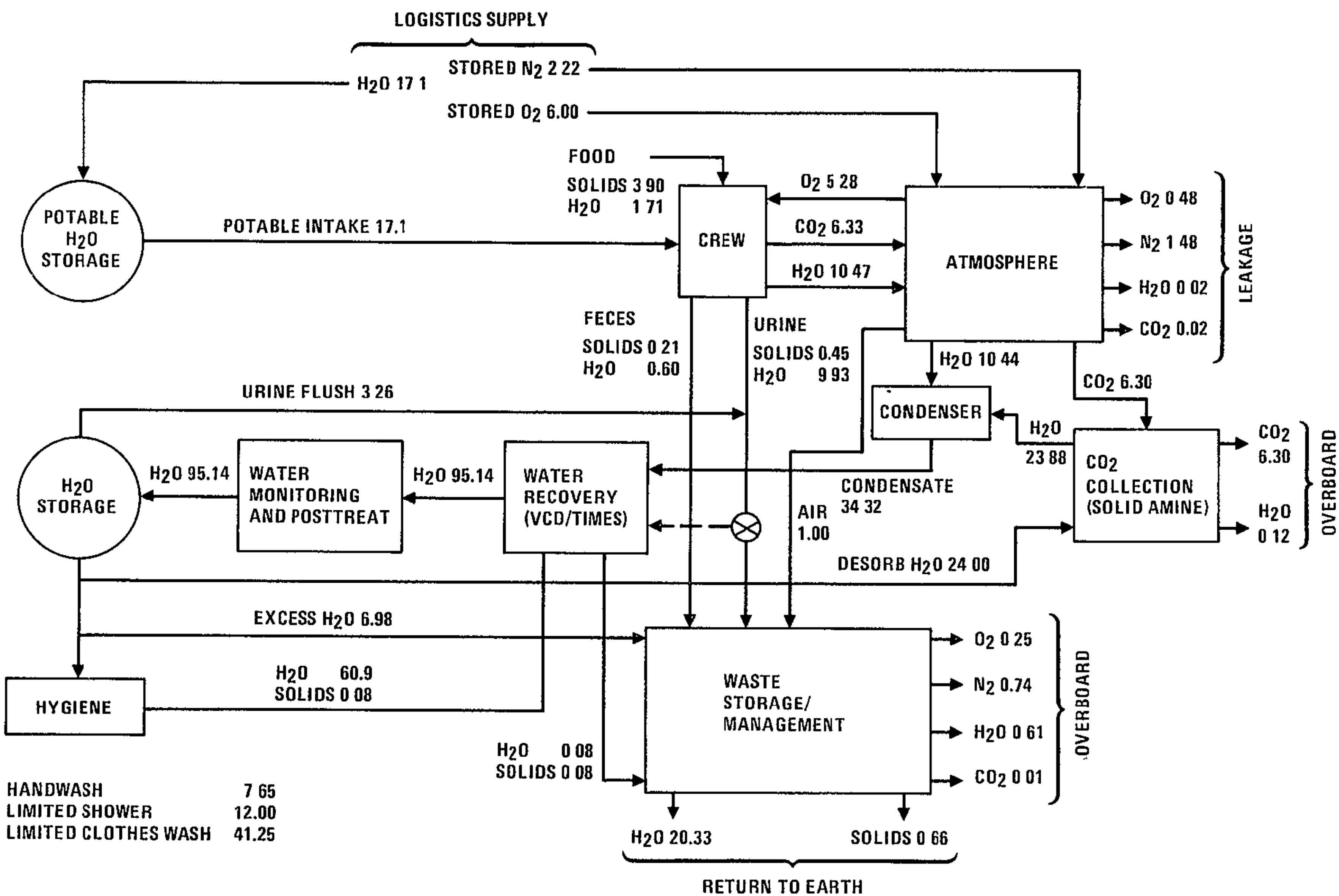
HAMILTON STANDARD

VFO646

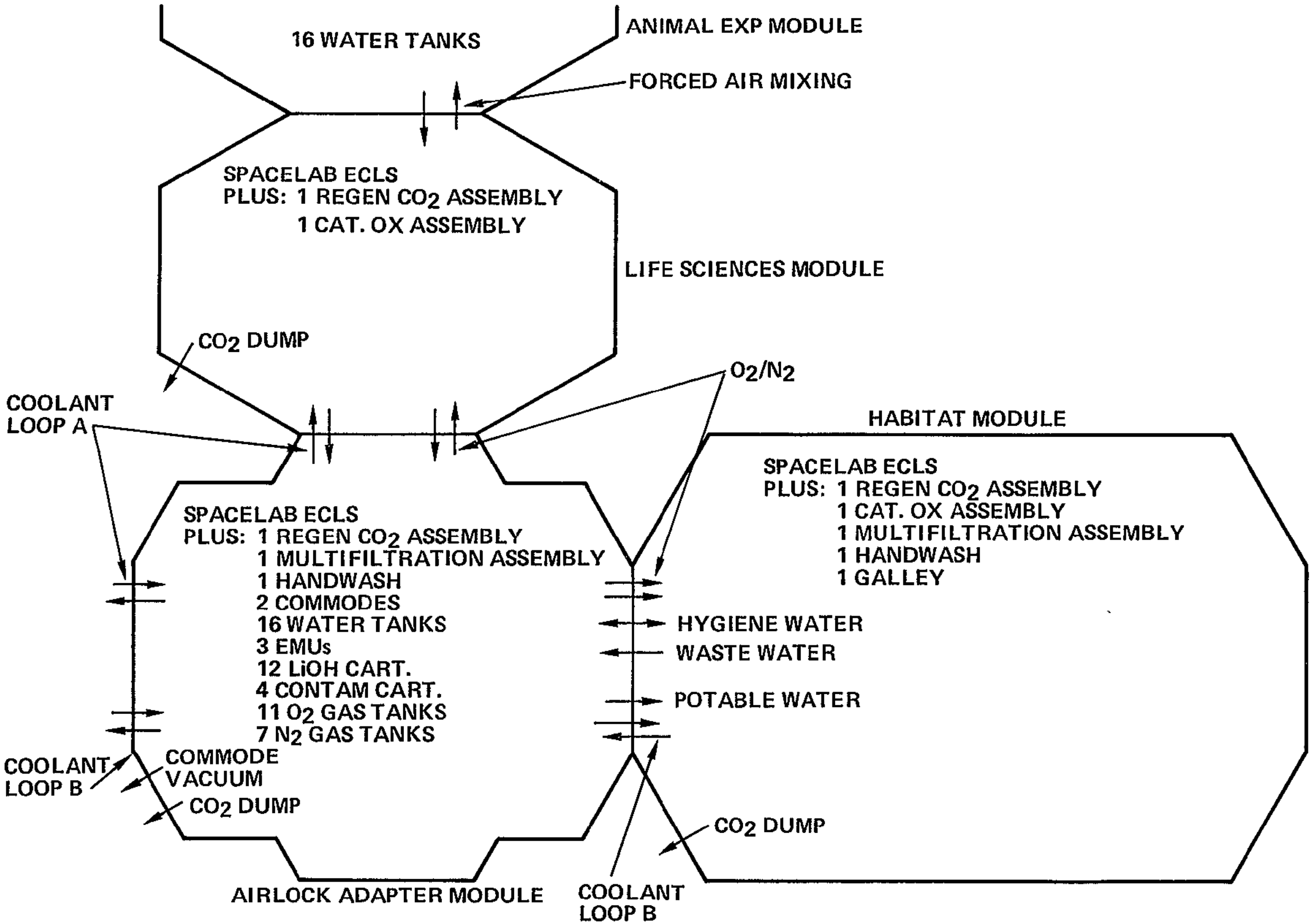
MSP ECLS INTERMEDIATE SYSTEM



HAMILTON STANDARD

BASIC MSP ECLS EQUIPMENT LOCATION

VFO648



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EXISTING HARDWARE APPLICABILITY FOR BASIC MSP

Existing Item	Remarks
Condensing Heat Exchanger	Use as Is
Fan Separators	Use as Is
Cabin Fan Package	Use as Is
Avionics Fan Package	Use as Is
Avionics Heat Exchanger	Use as Is
LiOH/Temperature Control Valve Package	Retain as Is But Use for Odor Control and Emergency CO_2 Removal
Water Pump Package	Use as Is
Potable/Wastewater Tanks	Use as Is
Two Gas Controller	Use as Is
N_2 Tanks	Use as Is
O_2 Tanks	Use as Is
Commode	Use as Is
Handwash	Use as Is
Galley	Use as Is
Suits and Backpacks	Use as Is
Miscellaneous Valves, Sensors, Etc	Use as Is

APPROACH TO LONG-LIFE/RELIABILITY APPROACH ENVIRONMENTAL CONTROL/LIFE SUPPORT SUBSYSTEM

VFO640

Existing Design

1. Already Designed for Long Life
2. Some Rotating Equipment Run in Excess of 20,000 hr (2-1/4 yr)
3. Qualification Times/Cycles Less Than 10 yr

Approach

1. Design for On-Orbit Maintenance
2. Trade Built-In Redundancy Versus Spares
3. Qualify on Orbit Where Practical
4. Include Built-In Redundancy Where Necessary for Fail-Operational/Fail-Safe

AIR COOLING VERSUS COLD PLATE COOLING

Consideration	Avionics Loop High Density (Per kW)	Avionics Loop Low Density (Per ft^3)	Cold Plate High Density (Per kW)	Cold Plate Low Density (Per ft^3)
Weight (lb)	37	1.6	16	1.5
Power (W)	164	4.1	0.7	0.1
Volume (ft^3)	5.4	0.4	1.4	0.1

Other Considerations:

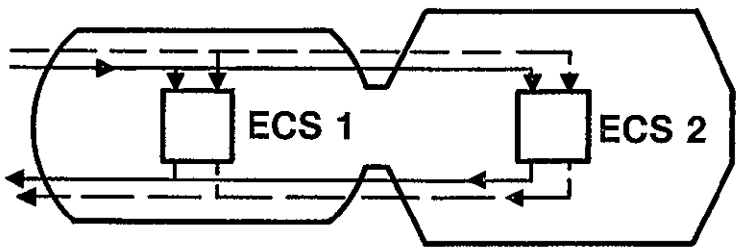
1. Unique Designs for Cold Plating
2. Water-Loop Pressure Drop Considerations
3. Air-Cooled Avionics Run About 15 to 20°F Hotter
4. Fire Detection

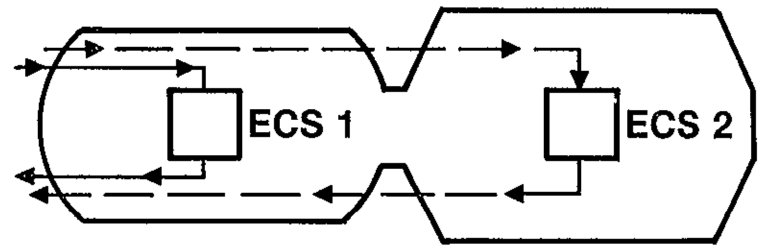
Conclusions:

Recommend Cold Plates Where Practical, Especially for High Power Density Applications

VFO649

WATER LOOP INTEGRATION OPTIONS





Each Loop to Both ECS

- Only One Loop Normally Operating
- Full Performance With One Loop Out
- More Expensive
- Poor Separation of Redundant Lines
- Orbiter Hardware

One Loop to Each ECS

- Maximum Separation of Redundant Lines
- Degraded Performance With One Loop Out
- Satisfies Two-Compartment Requirement
- Less Expensive
- Spacelab Hardware

ATMOSPHERE HUMIDITY AND TEMPERATURE CONTROL TRADE

Goals

- Use Spacelab Hardware
- Maximize Performance
  - Dew Point Below 60°F
  - Maximize Available Cooling
  - Low Load Capability
- Provide Capability to Grow
- Allow Reduced Cooling Water Flow Rate

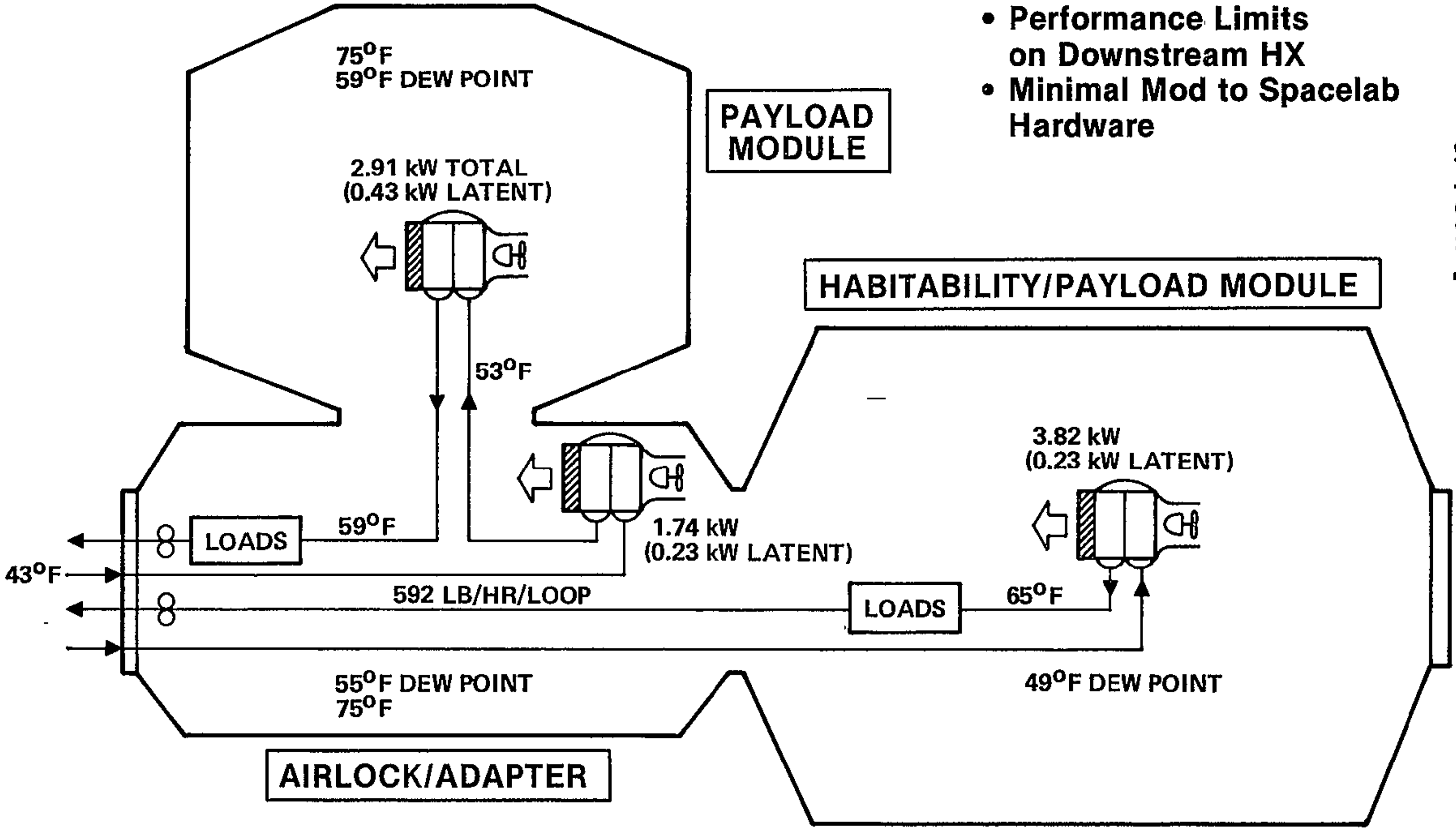
Options

- Dual Function (Each HX Cools Air and Controls Humidity)
  - Series Arrangement
  - Parallel Arrangement
- Separate Function
  - No Water Loop Temperature Control
  - With Temperature Control

VF0651

SERIES ARRANGEMENT OF DUAL-FUNCTION HEAT EXCHANGERS

- Controls Interaction
- Performance Limits on Downstream HX
- Minimal Mod to Spacelab Hardware



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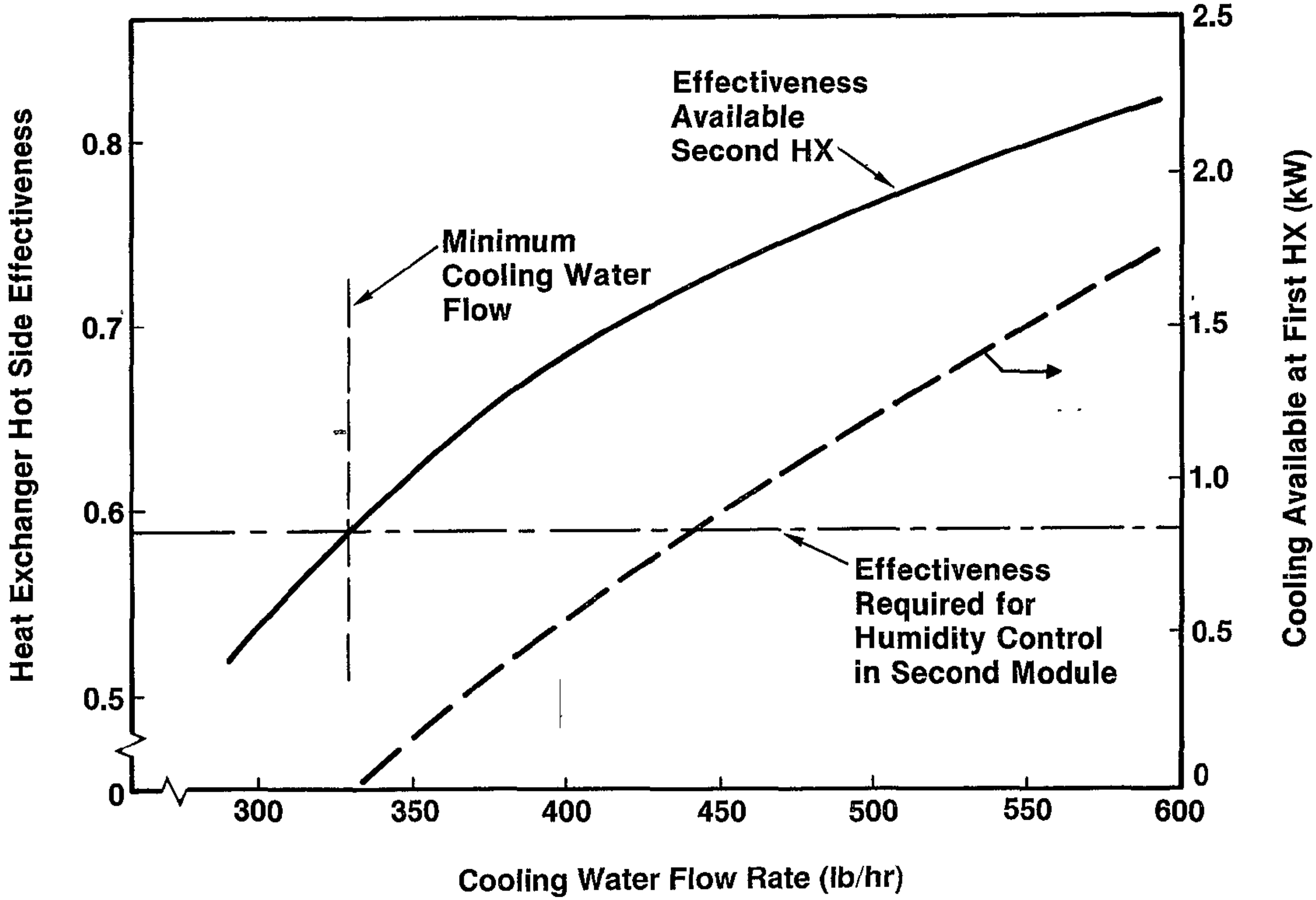
PERFORMANCE OF SERIES ARRANGEMENT OF DUAL-FUNCTION HEAT EXCHANGERS

VFO652



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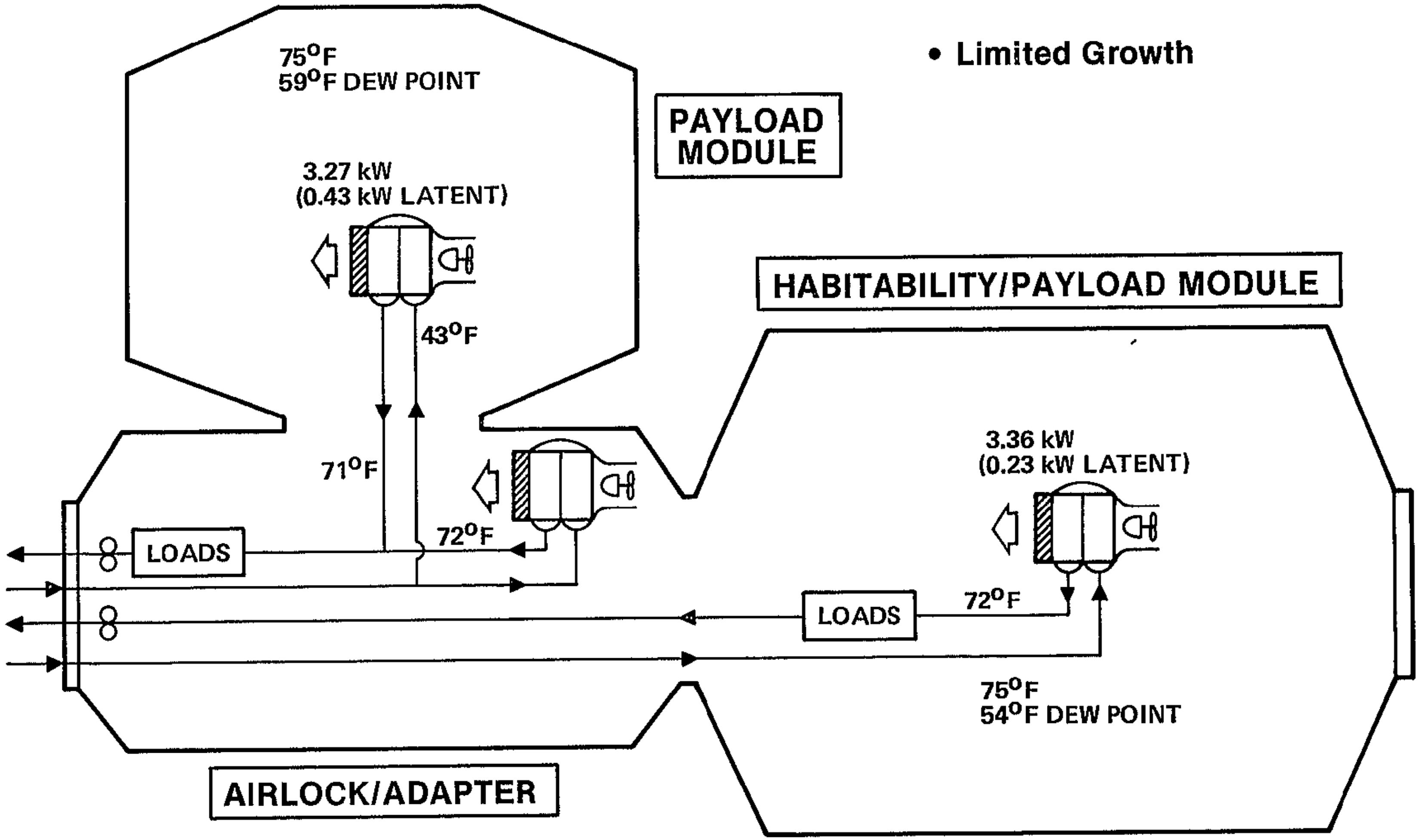
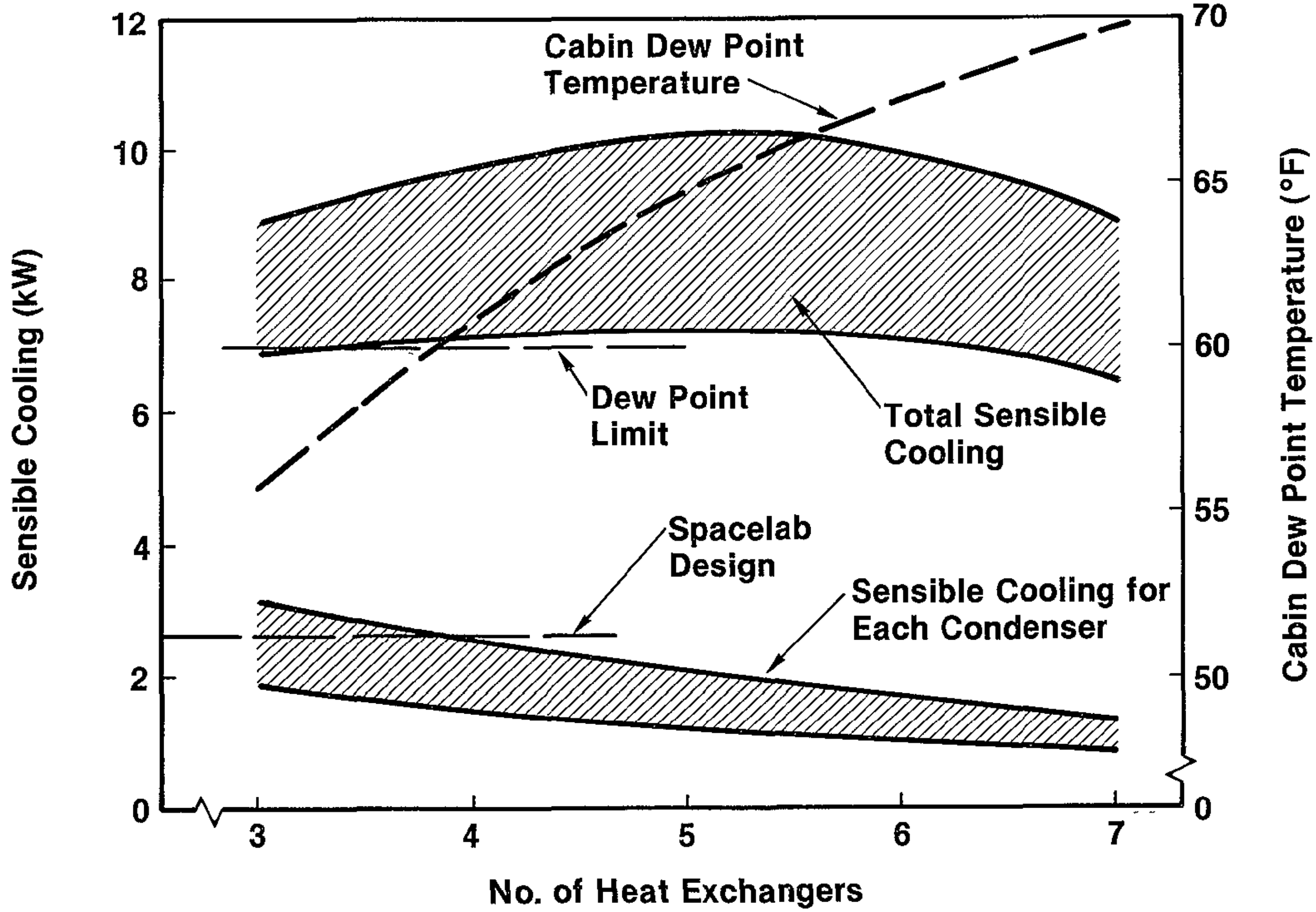
PARALLEL ARRANGEMENT OF DUAL-FUNCTION HEAT EXCHANGERS

- Marginal Humidity Control
- Limited Growth



PERFORMANCE FOR PARALLEL ARRANGEMENT OF DUAL-FUNCTION HEAT EXCHANGERS

VFO655



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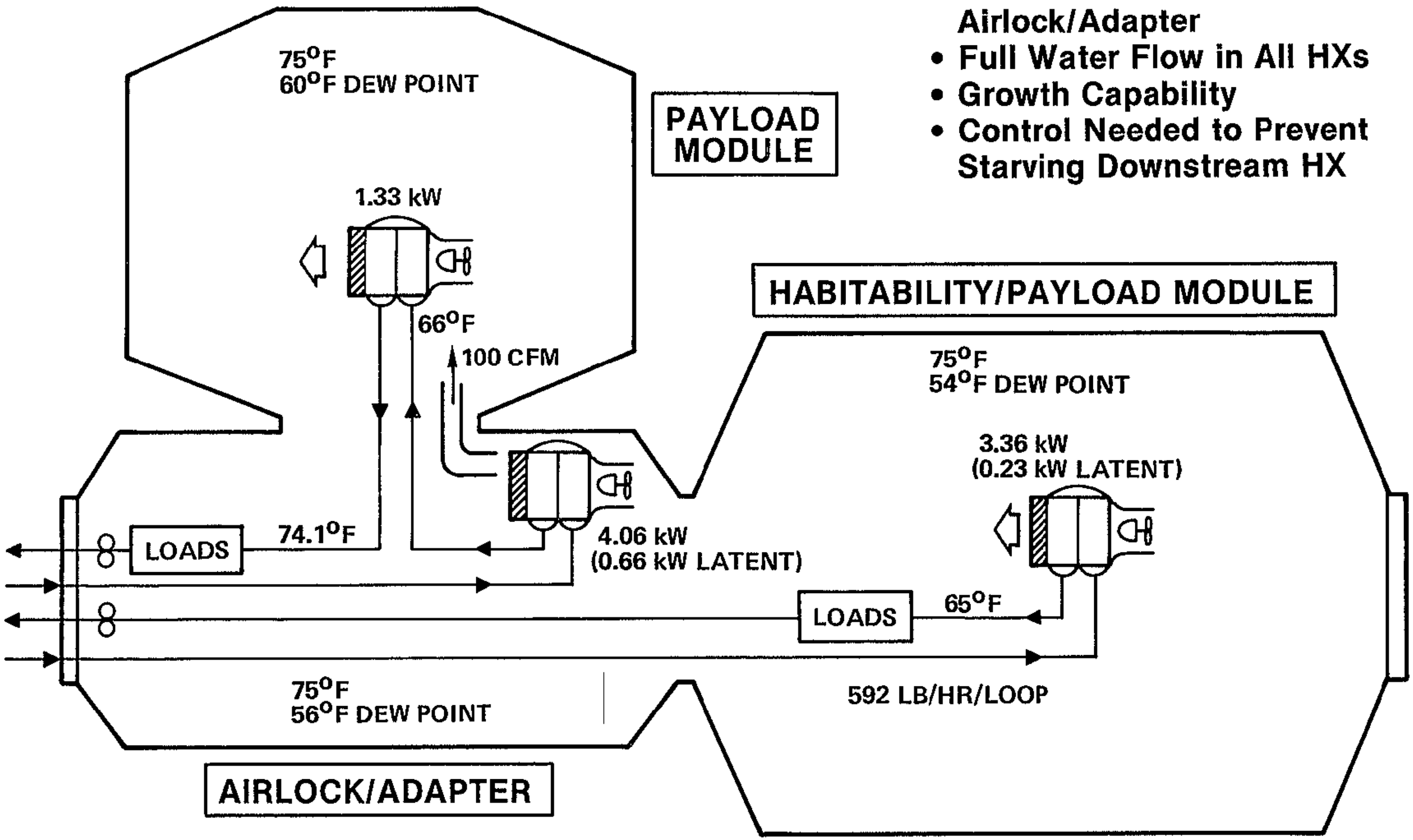
ALTERNATE CONCEPT FOR SERIES ARRANGEMENT OF DUAL-FUNCTION HEAT EXCHANGERS

VFO653

- No Minimum Load in Airlock/Adapter
- Full Water Flow in All HXs
- Growth Capability
- Control Needed to Prevent Starving Downstream HX



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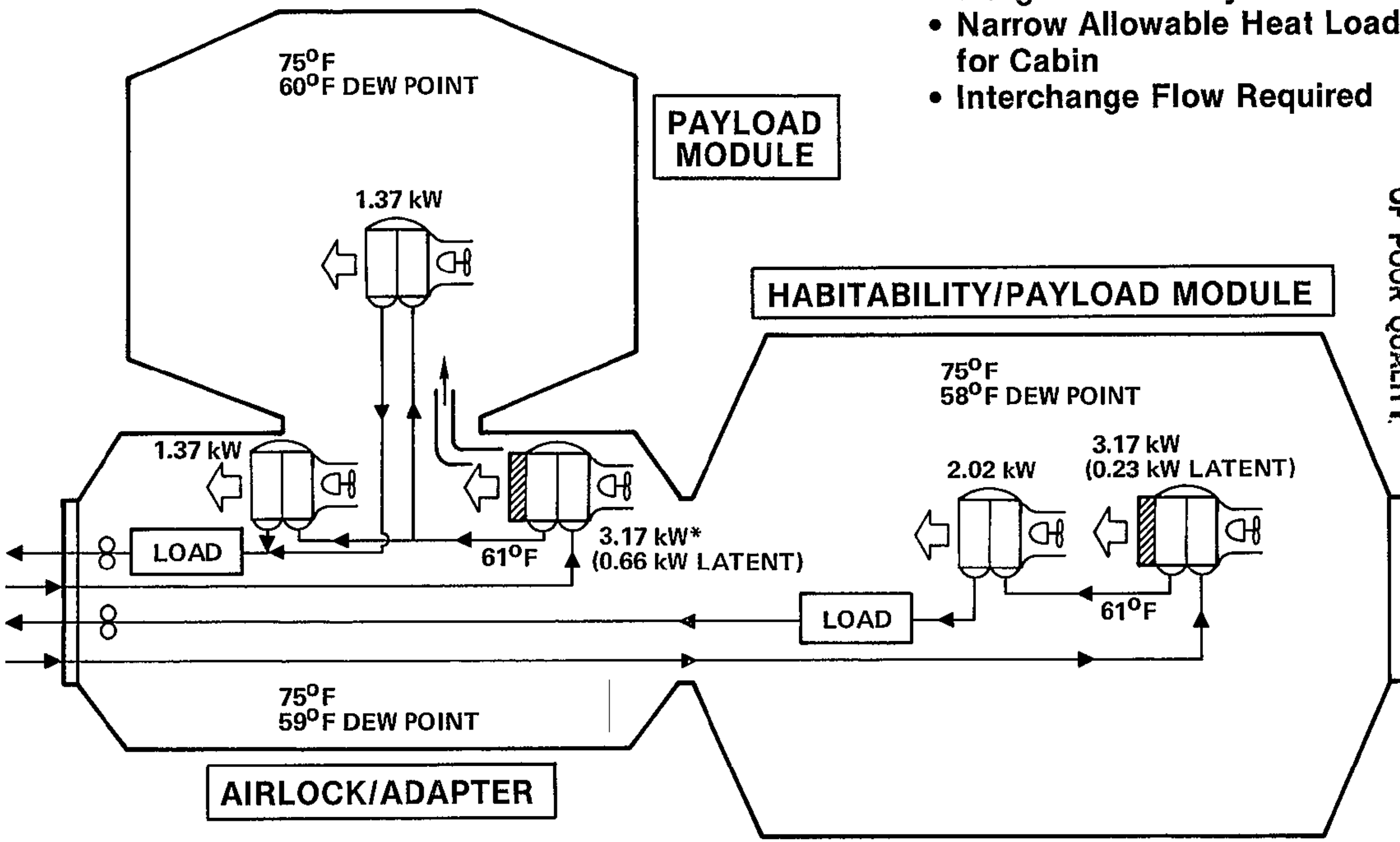
SEPARATE-FUNCTION HEAT EXCHANGERS WITH NO COOLING WATER TEMPERATURE CONTROL

VFO656

- Marginal Humidity Control
- Narrow Allowable Heat Loads for Cabin
- Interchange Flow Required



*A PORTION OF THIS COOLING AVAILABLE FOR PAYLOAD MODULE

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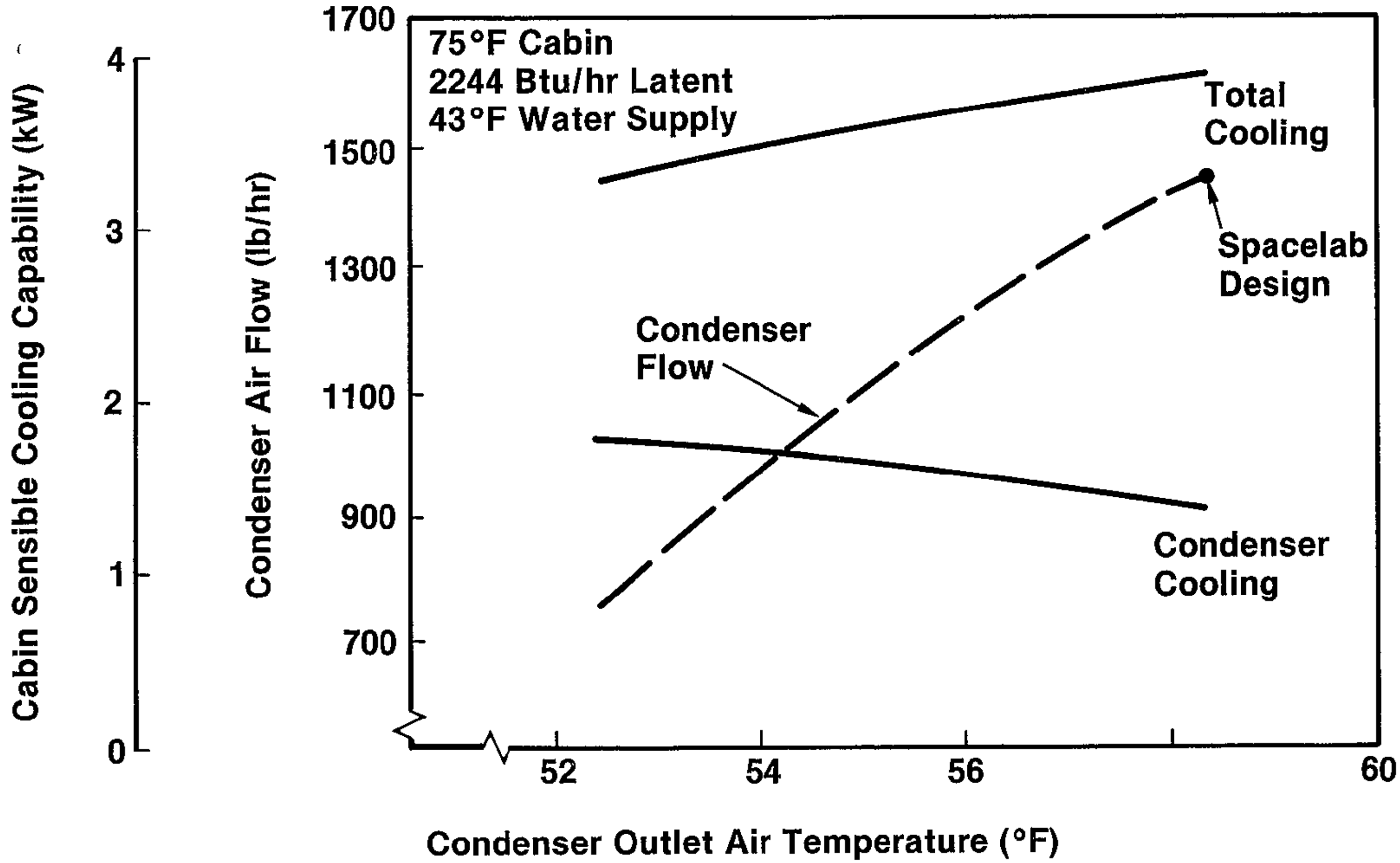
PERFORMANCE FOR SEPARATE-FUNCTION HEAT EXCHANGERS WITH NO COOLING WATER TEMPERATURE CONTROL

VFO657



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PERFORMANCE FOR SEPARATE-FUNCTION HEAT EXCHANGERS WITH COOLING WATER TEMPERATURE CONTROL

VFO658

- High Minimum Load for Condensers
- Larger Number of Heat Exchangers
- Interchange Air

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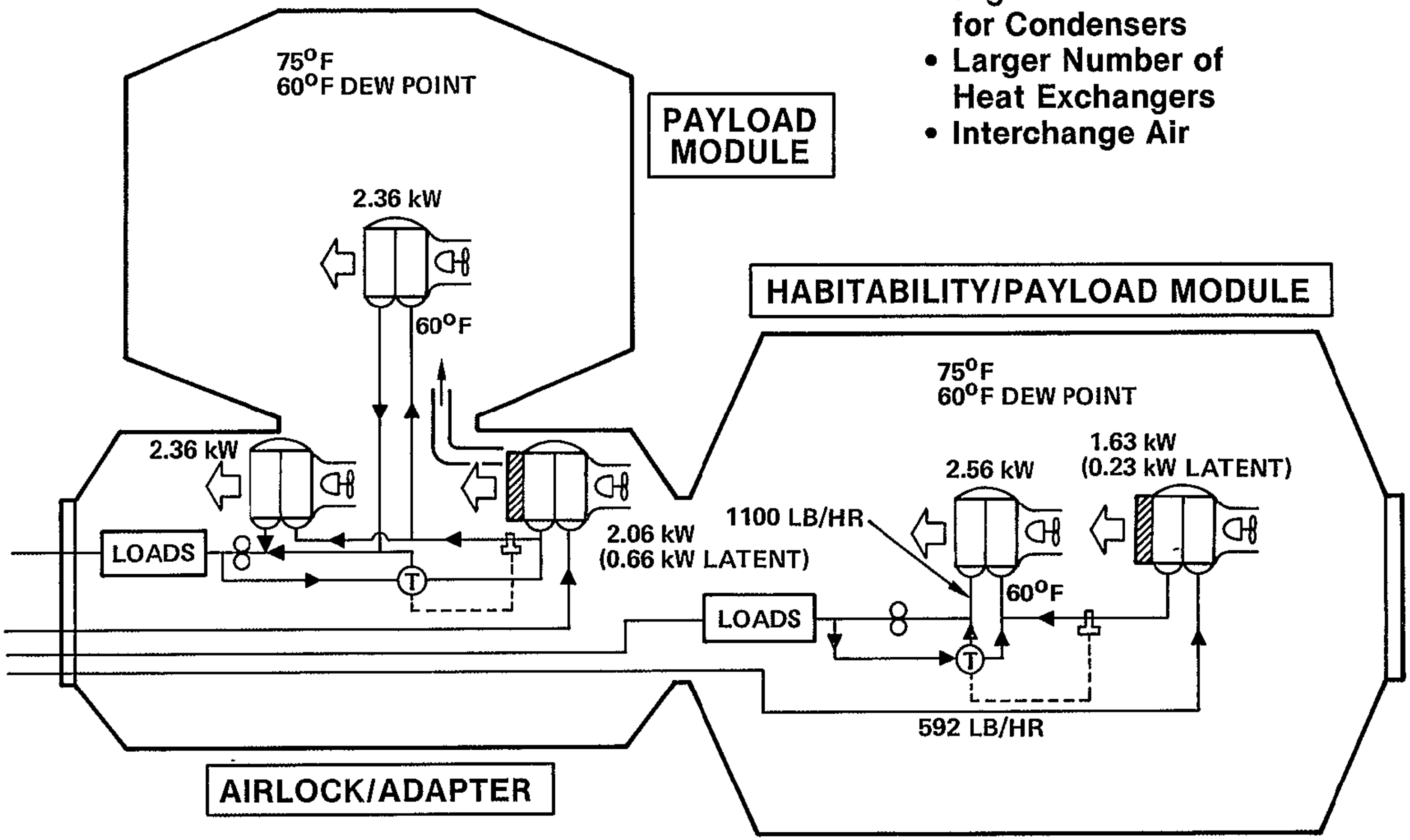


SUMMARY OF TRADE STUDY RESULTS ATMOSPHERE HUMIDITY AND TEMPERATURE CONTROL

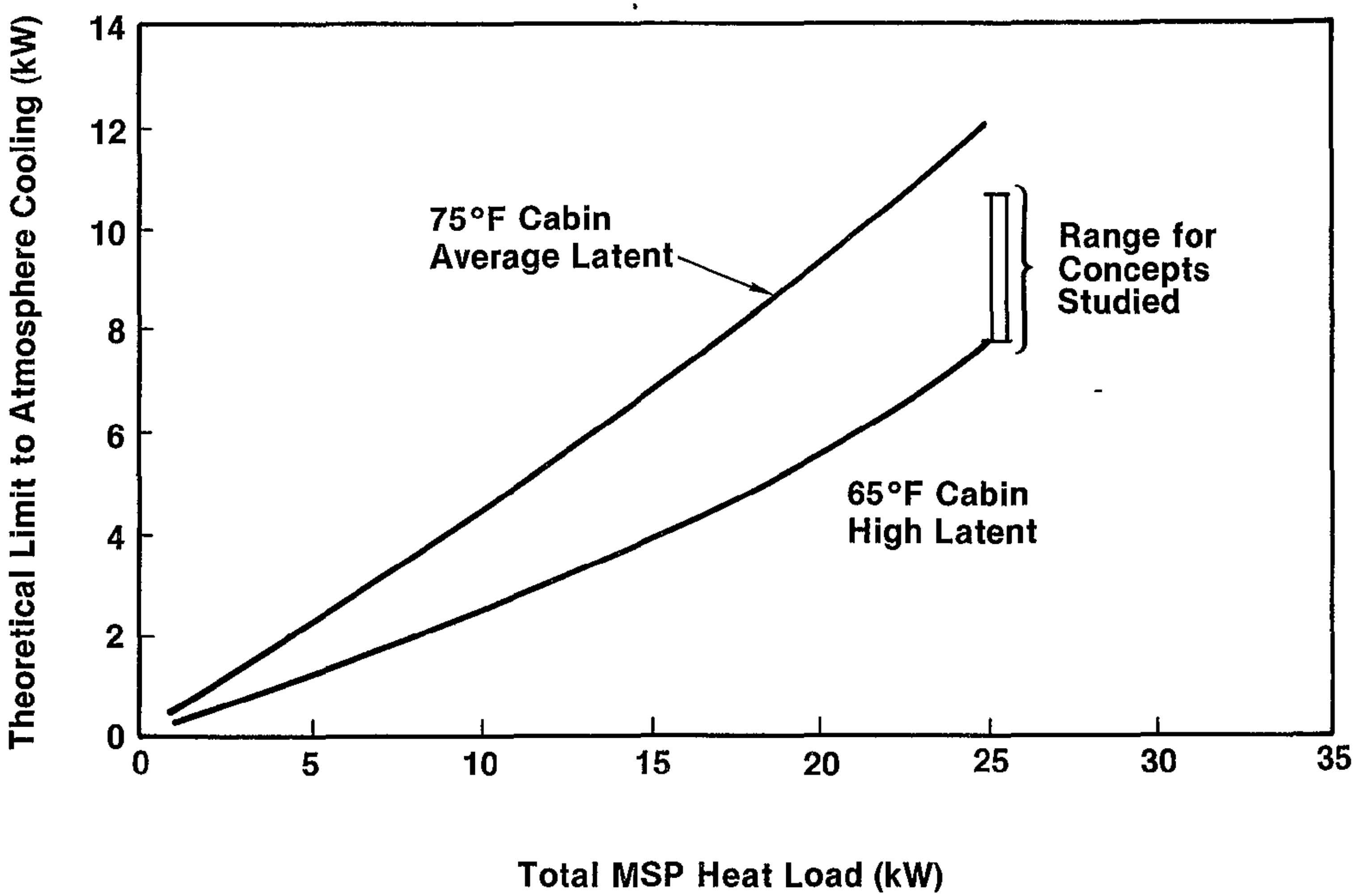
VFO659

Criteria	Dual-Function HXs: Series	Dual-Function HXs: Parallel	Separate-Function HXs: No Temperature Control	Separate-Function HXs: Temperature Control
Sensible Cooling				
Per Compartment (kW)	$\boxed{1.51}$-3.59	2.84-3.13	1.37-4.96	3.06-3.96
Total (kW)	$\boxed{7.59}$	9.11	11.22	10.08
Minimum Load (kW)	0	0	$\boxed{3.17}$	1.63(1)
Cabin Dew Point Temp (°F)	48-59	53-57	58-60	60
Penalties	Small	Small	2 Add HXs	$\boxed{\text{High}}$
Growth	$\boxed{\text{Single Module Limits}}$	$\boxed{\text{Limited}}$	Medium	Medium
Water Flow Sensitivity	Sensitive	$\boxed{\text{Very}}$	Medium	Minimal

(1) Function of Water Pump Design Flow

VFO660

THEORETICAL LIMITS FOR ATMOSPHERE COOLING



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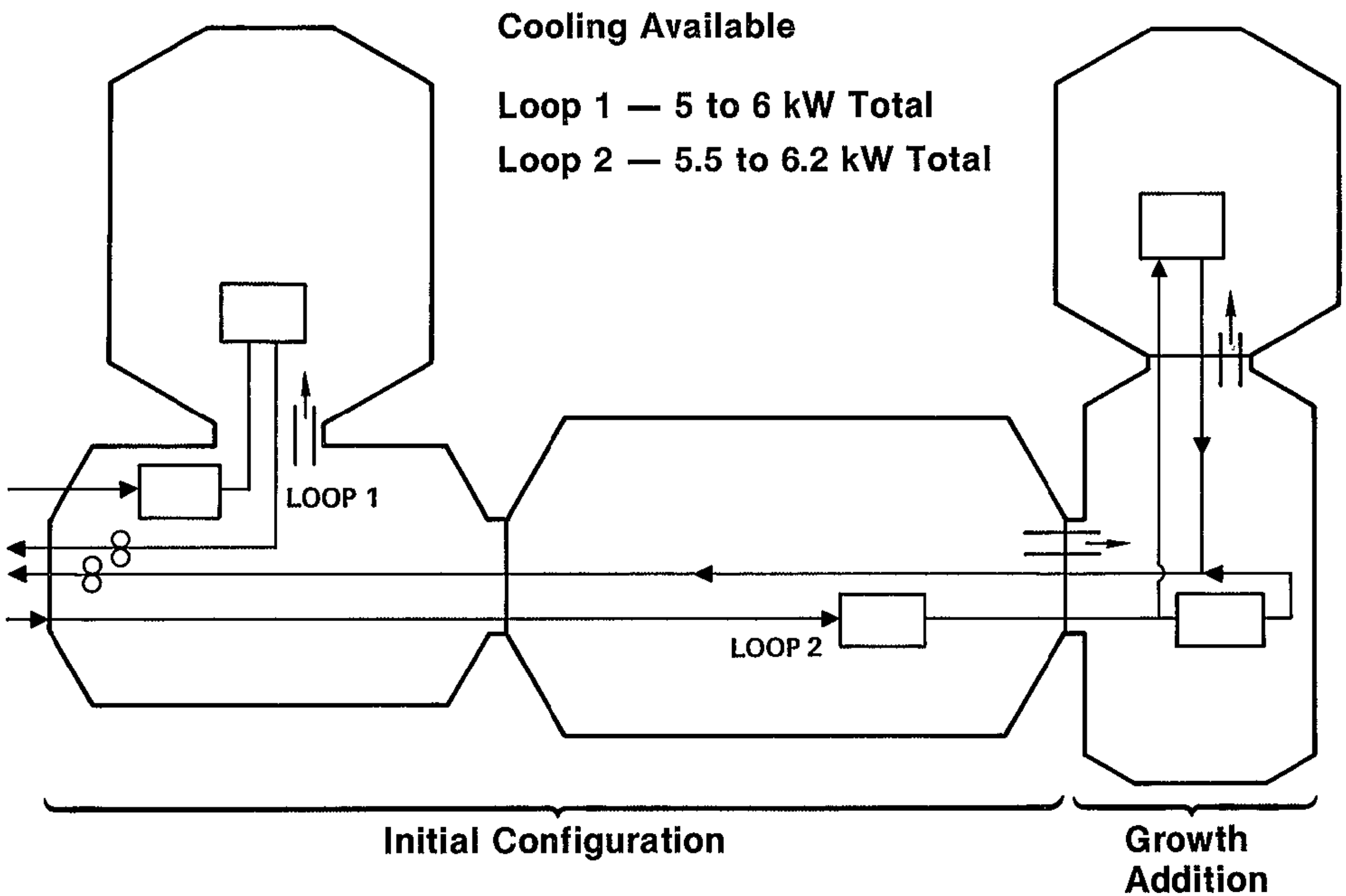
GROWTH CONCEPT FOR ATMOSPHERE HUMIDITY AND TEMPERATURE

VFO661



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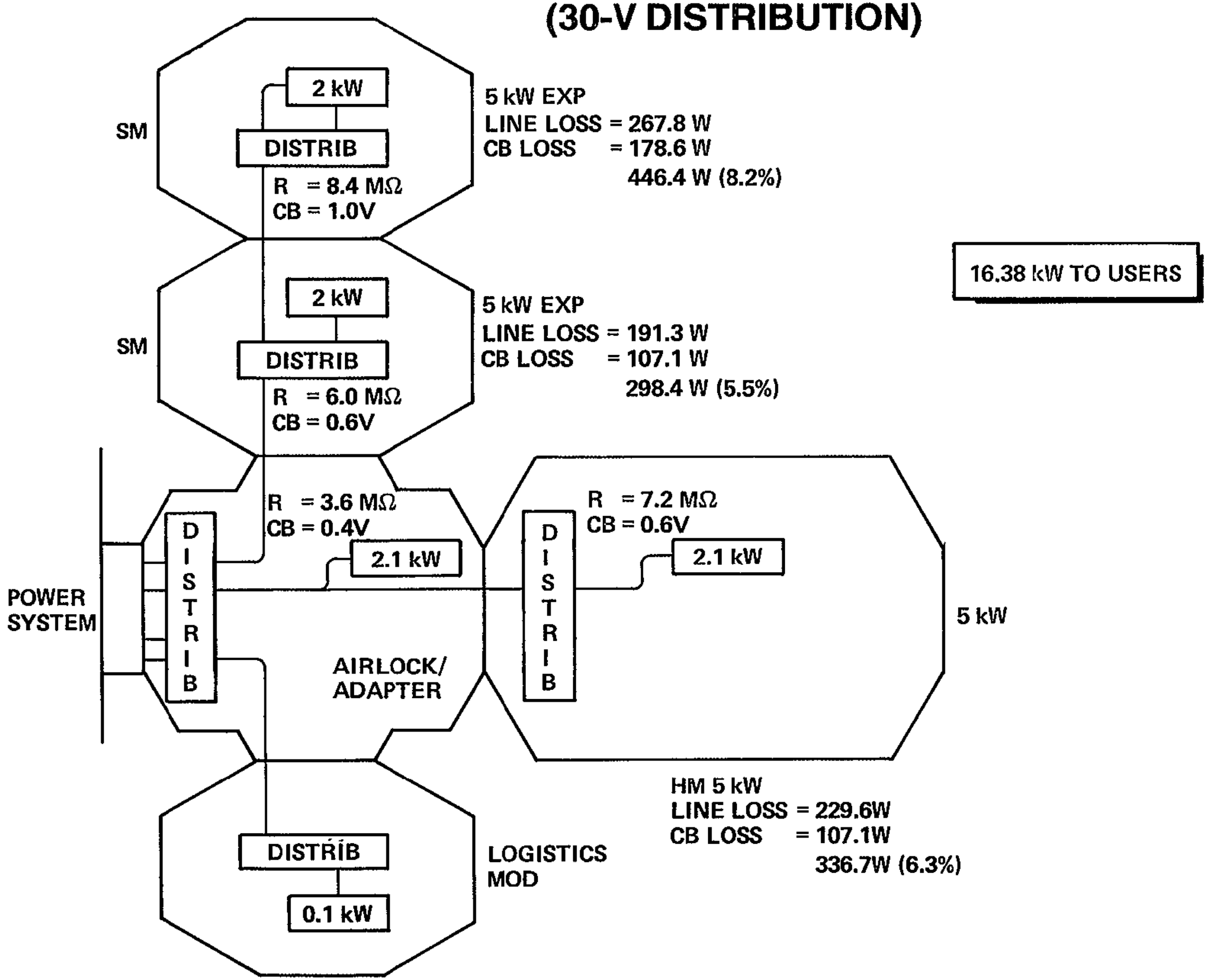
VFO748

POWER SUBSYSTEM ISSUES TO BE RESOLVED

- AC Power Distribution
  - Central vs Distributed Inverters
- DC Power Distribution For Distant Loads (Spacelab Impacts to be Considered. (30-V vs 120-V Distribution)
- Emergency Power Requirements
- Housekeeping Power Requirements
- PS and Spacelab Equipment Capabilities/Limitations
- Power Management

DC POWER DISTRIBUTION - INITIAL VERSION (30-V DISTRIBUTION)



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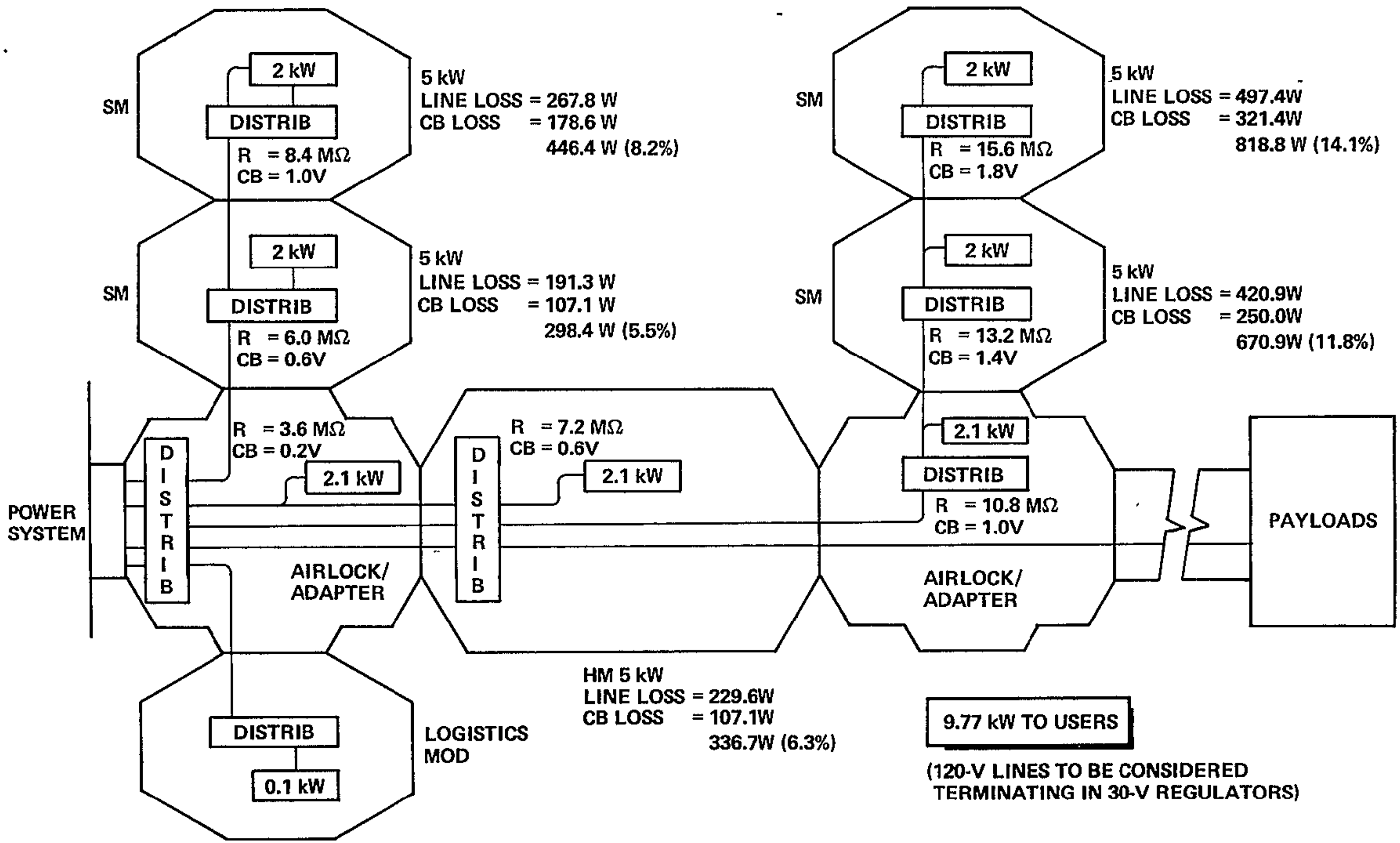
DC POWER DISTRIBUTION - GROWTH VERSION (30-V DISTRIBUTION)

VFO747



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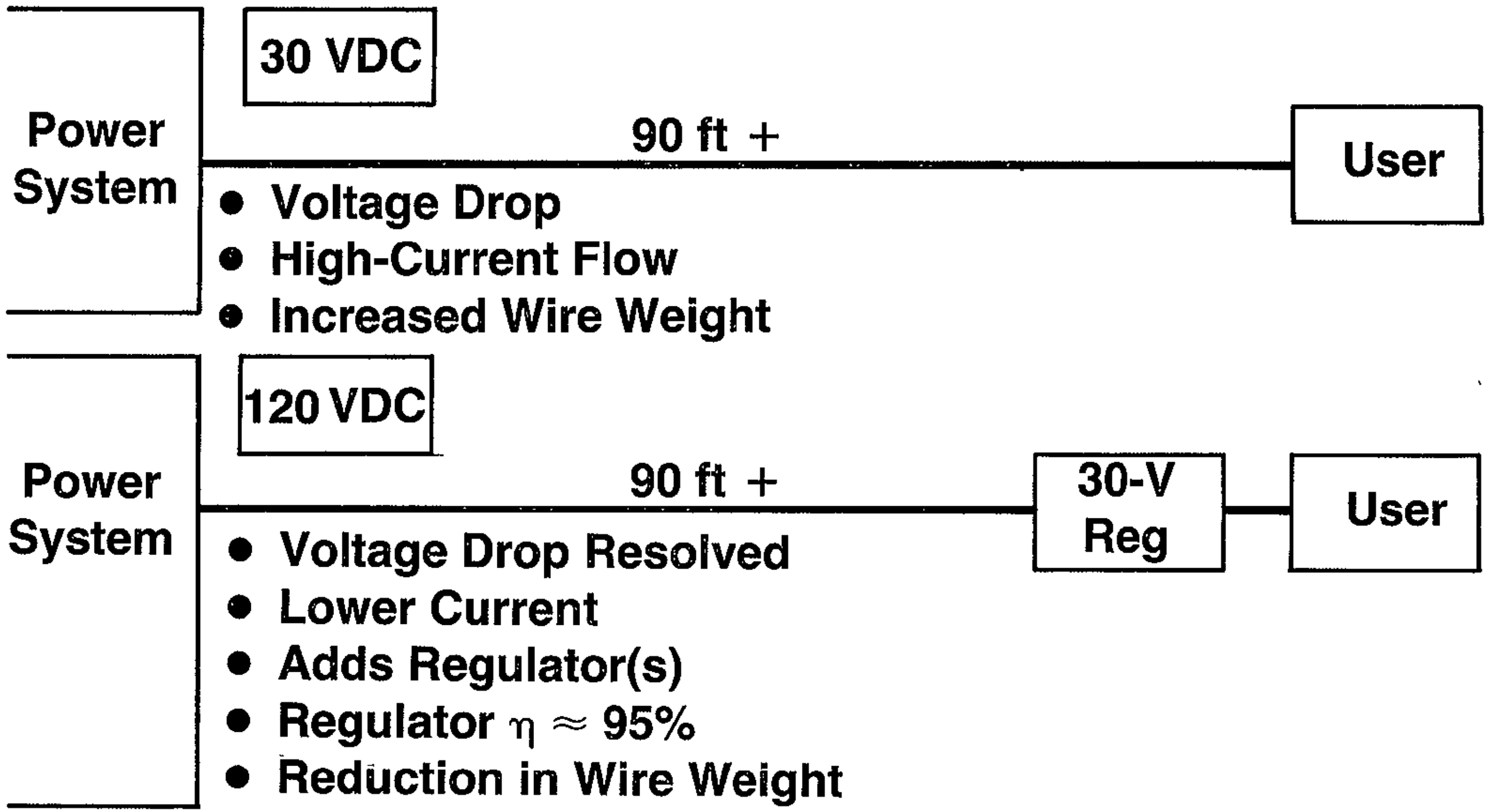
TRANSMISSION VOLTAGE CONSIDERATIONS FOR DISTANT LOADS



VFO662

CDMS DESIGN APPROACH

Operational Mode Assumptions

- Initial Shuttle-Tended Mode
  - Airlock/Adapter or AFD Control Center
- Manned Free-Flyer Mode
  - Habitat Module Contains Primary Control Center
  - Airlock/Adapter Has Backup Capability

Hardware Selection Options

- Spacelab-Derived
- Other Current-Technology Hardware
- New-Technology Hardware

Additional Redundancy for Increased Reliability

Minimize Impact to Power System and Orbiter

Provide Capability for Evolutionary Platform Growth

CDMS FUNCTION ALLOCATION

Function	Power System	Platform				
		Airlock Adapter	Payload Module	Habitat	Logistics Module	Beam
Communications and Tracking						
Voice Intercom		X	X	X		
EVA		X				
Detached Vehicle		X(G)				
Ground (TDRSS)	X					
Data Handling						
Acquisition	X	X	X	X	X	X
Distribution	X	X	X	X	X	X
Processing	X	X(I)	X(P/L)	X		
Storage	X		X(P/L)	X(I)	X(Film)	
Display/Crew Input		X		X		
Closed-Circuit TV						
Cameras	X	X	X	X		X
Monitors				X		
C&W/Safing						
Annunciation		X	X	X	X	
Controls		X	X	X	X	
Processing				X(I)		
Timing						
Generation	X					
Distribution	X	X	X	X		X
Timing Displays		X		X		
(G) Growth (I) Initial						

CANDIDATE CDMS HARDWARE APPROACHES

- Spacelab/Shuttle Hardware
- STACC Hardware (Ref PS Approach)
- FMDM Hardware
- New-Technology Hardware

VFO665

CDMS SELECTION CRITERIA

- Requirement Accommodation
- Flexibility/Growth Capability
- Cost/Cost Risk
- Reliability
- Volume, Weight, and Power
- Compatibility With Other Subsystems
- Availability/Schedule Risk

VFO666

COMPARISON OF CDMS HARDWARE APPROACHES

Approach	Advantages	Disadvantages
Spacelab/Shuttle	• Developed • Low Risk • Compatible With Orbiter	• Reliability
STACC	• Developed • Qualified for Long Mission Life	• Capacity • Flexibility • No Man/Machine Interface
FMDM	• Potential for Distributed Processing • Flexible	• No Man/Machine Interface
New-Technology Hardware	• Potential Improvements in Performance, Reliability and Packaging	• Requires Development and Qualification • Cost Risk

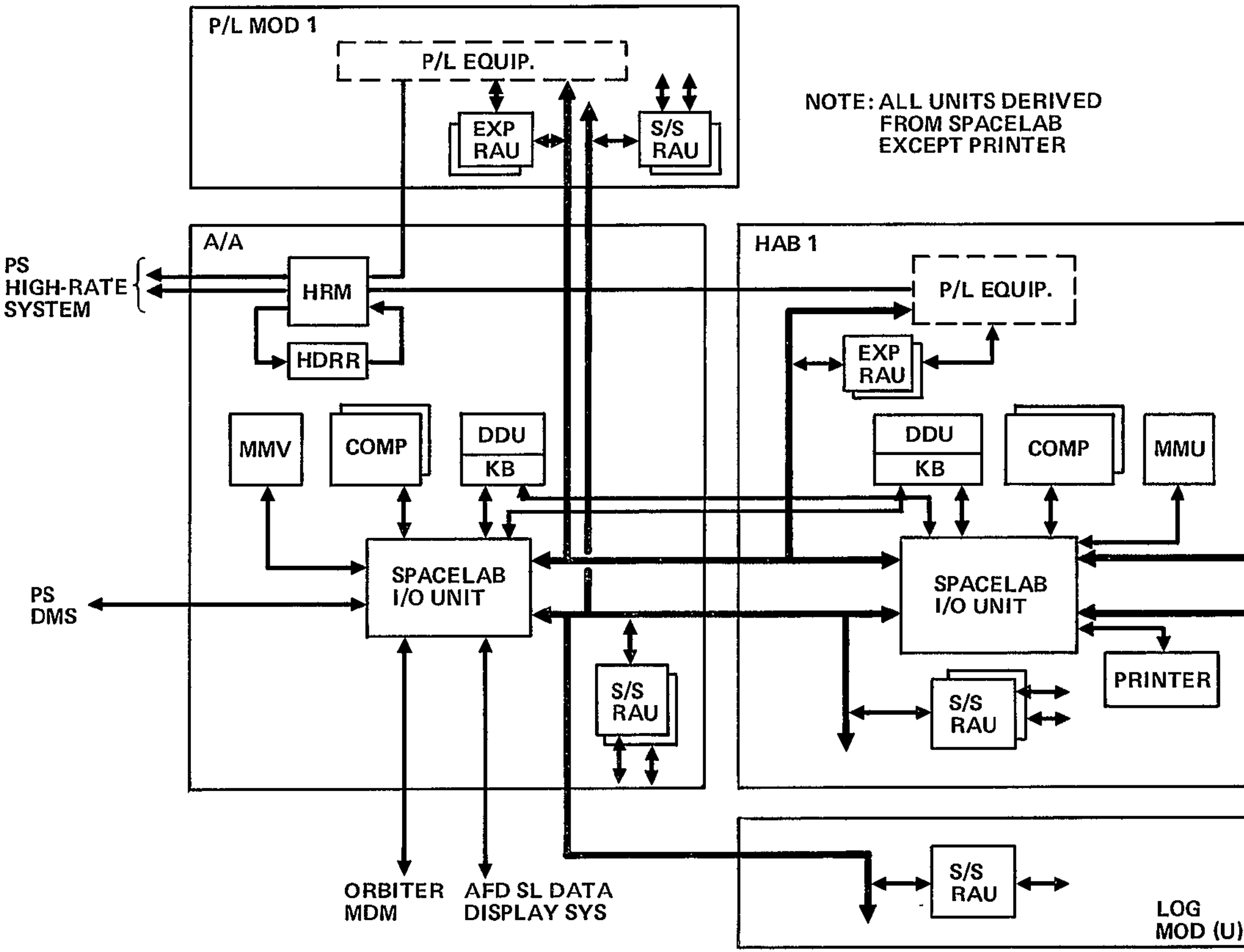
SELECTED

CDMS FEATURES

- Utilizes Developed Equipment
- Provides Flexible Crew Accommodation
- Accommodates PS and Orbiter Interfaces
- Exhibits Improved Reliability
- Accommodates Platform Growth

PLATFORM
DATA MANAGEMENT SUBSYSTEM

VFO667



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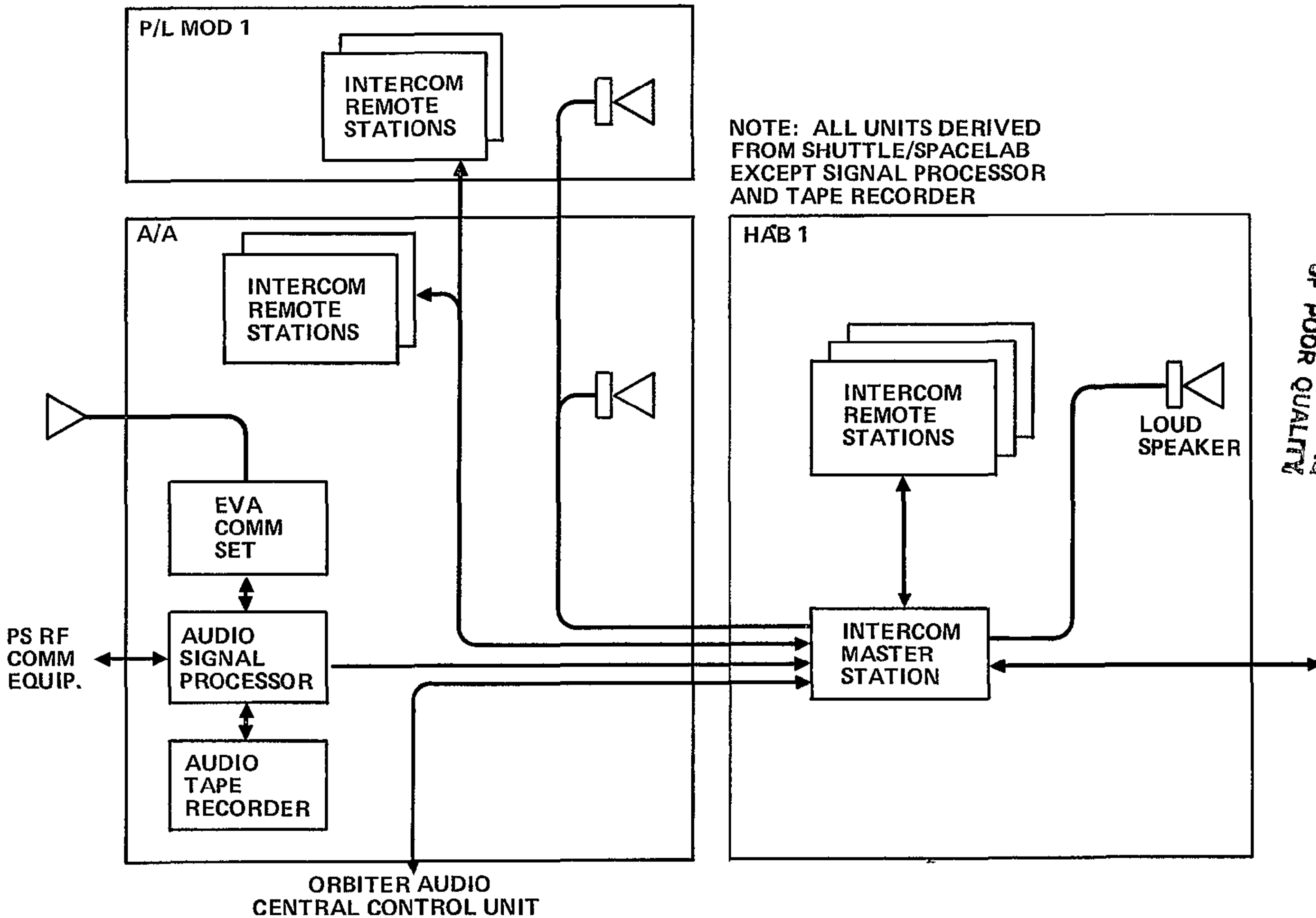
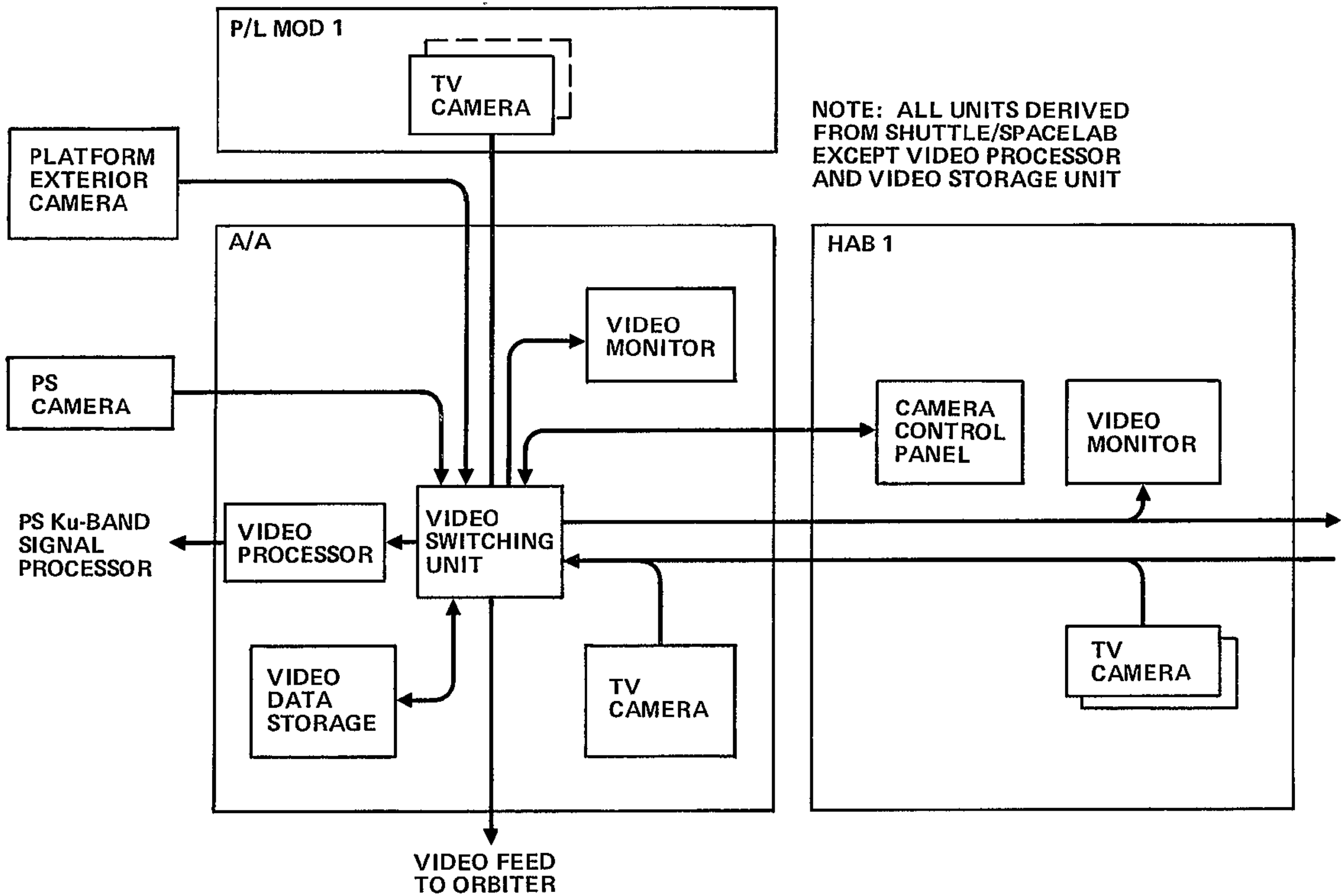
VFO669

PLATFORM
VOICE COMMUNICATION SUBSYSTEM



VFO668

PLATFORM
CLOSED-CIRCUIT TV SUBSYSTEM

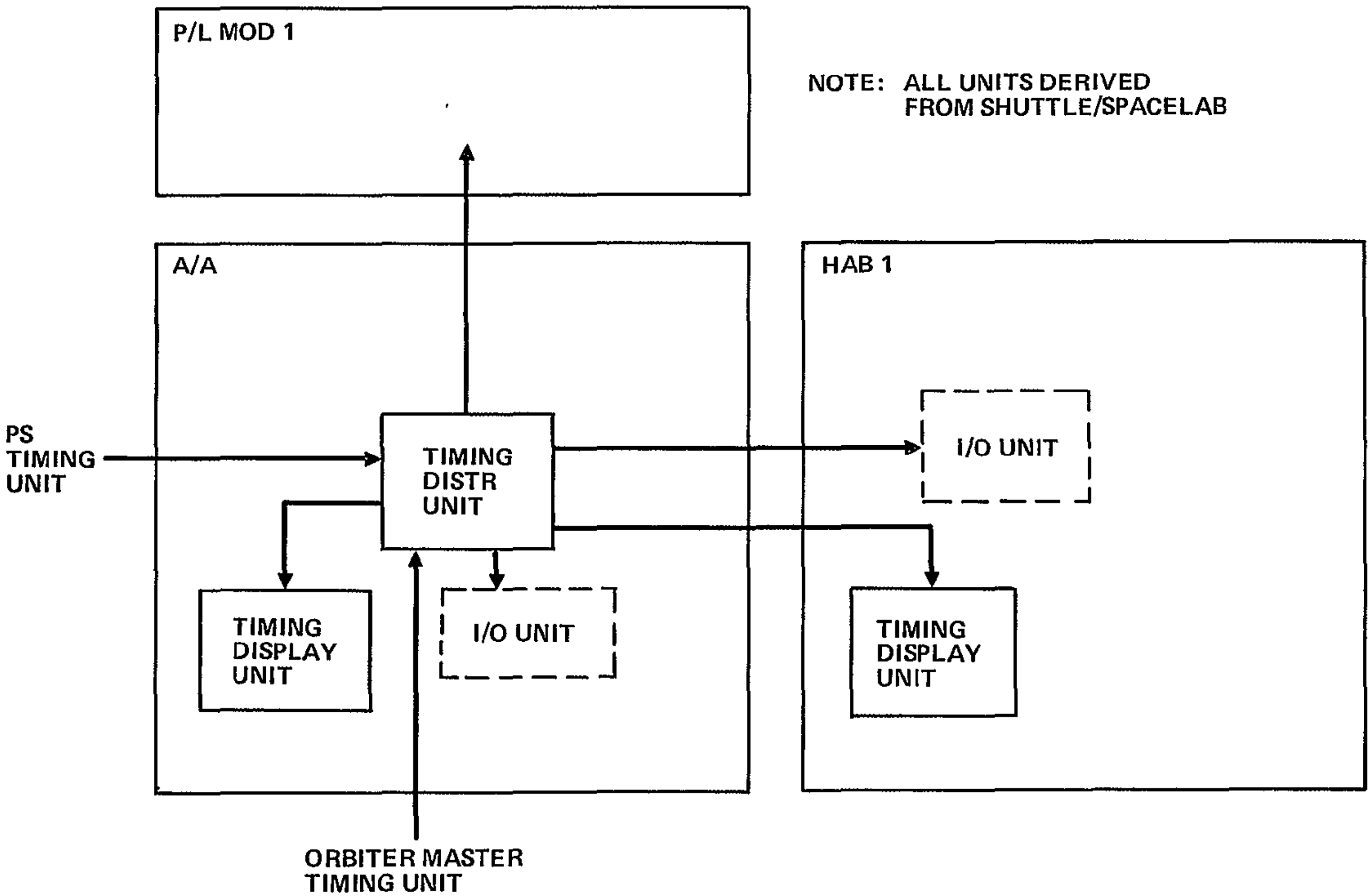


NOTE: ALL UNITS DERIVED FROM SHUTTLE/SPACELAB EXCEPT VIDEO PROCESSOR AND VIDEO STORAGE UNIT

VFO671

PLATFORM TIMING DISTRIBUTION

NOTE: ALL UNITS DERIVED FROM SHUTTLE/SPACELAB



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CDMS EQUIPMENT SUMMARY

Unit	Pedigree	Utilization: Airlock/Adapter	P/L Mod	Hab Mod	Log Mod
I/O Unit	Spacelab	1		1	
DDU/KB	Spacelab	1		1	
Computer	Spacelab	2		2	
MMU	Spacelab	1		1	
Exp RAU	Spacelab		2	2	
Subsys RAU	Spacelab	2	2	2	1
HRM	Spacelab	1			
HDRR	Spacelab	1			
Printer	New			1	
TV Camera	Orbiter	1	1	2	
Video Monitor	Spacelab	1		1	
Video S/W Unit	Orbiter	1			
Video Processor	New	1			
Video Storage Unit	New	1			
Camera Control Pnl	Orbiter			1	
Intercom Master Sta	Spacelab			1	
Intercom Remote Sta	Spacelab	2	2	3	
Loudspeakers	Spacelab	1	1	2	
EVA Comm Set	Orbiter	1			
Audio Sig Proc	New	1			
Audio Recorder	New	1			
C&W Processor	Orbiter			1	
C&W Distr Unit	New	1			
C&W Annunciator Pnl	Orbiter	1	1	1	
Timing Distr Unit	Orbiter	1			
Timing Display Unit	Orbiter	1		1	

IMPACT OF 2- VERSUS 3-SEGMENT MODULE ON CDMS HARDWARE

VFO678

- 1 or 2 Additional Experiment RAUs
- 1 or 2 Additional Subsystem RAUs
- Extend Data Buses
- Additional Intercom Remote Station(s)

VFO677

CDMS APPROACH TO POWER SYSTEM COMPATIBILITY

Issues

- Man-Rated Design
- Interface Compatibility
- Support Costs (Common Spares)

Approach

- PS Initial Design for Manned Safety
- PS Interface Adaptation in Airlock/Adapter Option: Use Single Design Approach From Start

CDMS OPEN ISSUES

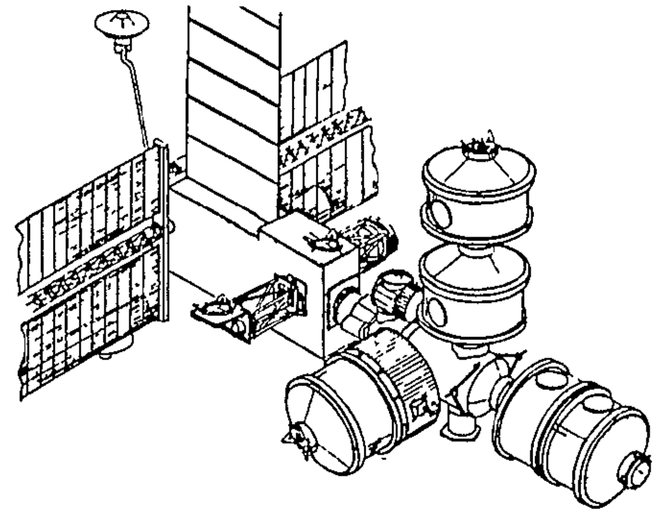
CDMS Reliability

- Additional Redundancy
- Onboard Spares, Fault Isolation, Repair
- Design/Manufacturing Upgrades

Utilization of New Technology

- Distributed Data Processing
- Improved IC and Computer Technology
- Fiber Optic Data Transmission
- Voice Recognition and Synthesis
- Display Technology

MSP/POWER SYSTEM ACS CAPABILITY ANALYSIS



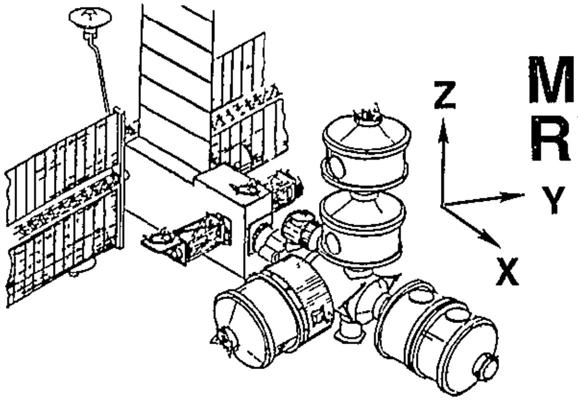
Reference Power System (25 kW)

- Three Modified Skylab CMGs
- Four Space Telescope Magnetic Torquers

Conditions Analyzed

- 200 and 235 nmi Altitudes
- 0, 40, and 80 deg β-Angles
- 57.5-deg Inclination
- Medium, High, and Worst-Case Atmospheric Densities
- June 21 — Time of Year
- Five Inertial Orientations
- Two Local Vertical Orientations

VFO725



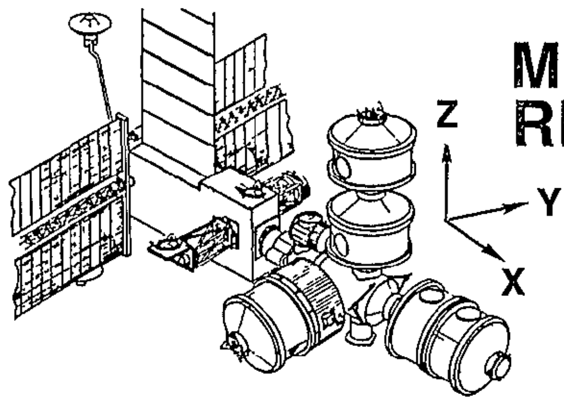
MSP ORIENTATION DURATION WITH REFERENCE 25KW POWER SYSTEM

Medium Atmospheric Density

Principal Axes Orientation	β (deg)	Orientation Hold Duration (Orbits): 235 nmi			Orientation Hold Duration (Orbits): 200 nmi		
		0	40	80	0	40	80
XPOP-YPSL		∞	∞	∞	∞	∞	∞
XPOP-ZPSL		∞	∞	∞	∞	∞	∞
YPOP-ZPSL		∞	∞	∞	6	800	∞
ZPOP-YPSL		62	∞	∞	5	∞	∞
ZSI-XIOP		∞	3	27	9	2	13
ZLV-XPOP (YVV)		14	18	17	2	2	2
ZLV-YPOP (XVV)		∞	∞	∞	∞	∞	∞

Three Skylab CMGs and Four Space Telescope Electromagnets

VFO723



MSP ORIENTATION DURATION WITH REFERENCE 25KW POWER SYSTEM

High Atmospheric Density

Principal Axes Orientation		Orientation Hold Duration (Orbits)					
		235 nmi			200 nmi		
	β (deg)	0	40	80	0	40	80
XPOP-YPSL		∞	∞	∞	130	∞	∞
XPOP-ZPSL		∞	∞	∞	<1	∞	∞
YPOP-ZPSL		8	∞	∞	2	9	∞
ZPOP-YPSL		7	∞	∞	1	40	∞
ZSI-XIOP		26	3	19	1	1	8
ZLV-XPOP (YVV)		2	2	2	1	1	1
ZLV-YPOP (XVV)		∞	∞	∞	33	36	27

Three Skylab CMGs and Four Space Telescope Electromagnets

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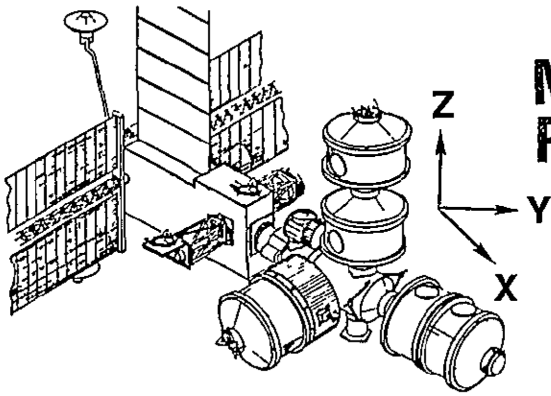


MSP ORIENTATION DURATION WITH REFERENCE 25KW POWER SYSTEM

Worst-Case Atmospheric Density

Principal Axes Orientation	β (deg)	Orientation Hold Duration (Orbits) 235 nmi 0	235 nmi 40	235 nmi 80	200 nmi 0	200 nmi 40	200 nmi 80
XPOP-YPSL		∞	∞	∞	<1	<1	∞
XPOP-ZPSL		∞	∞	∞	<1	∞	∞
YPOP-ZPSL		5	∞	∞	<1	<1	<1
ZPOP-YPSL		4	∞	∞	<1	40	∞
ZSI-XIOP		3	1	14	<1	<1	7
ZLV-XPOP (YVV)		1	1	1	<1	<1	<1
ZLV-YPOP (XVV)		∞	∞	∞	9	9	8

Three Skylab CMGs and Four Space Telescope Electromagnets

MSP/POWER SYSTEM ACS CAPABILITY SUMMARY

VFO721

- XPOP-YPSL Orientation Best Suited For Long-Term, High-Power Operations
- ZLV-YPOP Orientation Is Acceptable For Low-β-Angle Operations
- Orientation Restrictions For Low Altitudes and High and Worst-Case Atmosphere Conditions
- Additional CMGs and Electromagnets Desirable To Increase Orientation Flexibility and Margins For Uncertainties, Failures and Maneuvers

SAFETY/RELIABILITY SUBJECTS

- Comparison of Safety/Reliability Criteria, MSP Versus Power System
- Built-In Redundancy Versus Spares/Maintenance
- Approach to Safety and Reliability
- Meteoroid Protection

VFO632

COMPARISON OF SAFETY/RELIABILITY CRITERIA

MSP	Power System
No Single-Point Failure *or Credible Combination* Endangers Crew Members or Causes Abandonment of Platform	No Single-Point Failure Prevents PS Recovery or Causes Loss of Mission
Capability for On-Orbit Repair	Maintainable On-Orbit to Orbital Replacement Unit (ORU)
Fault Isolation, Checkout, and Built-in-Test Capability	Fault Isolation to ORU Level; Verification of Critical System Elements
Provide for Crew Rescue *(180 hr)*	Safe-Hold Capability for 24 to 72 hr
Subsystem Design for Minimum Risk to Subsystems and Crew Injury, and No Propagation of Failures	No Propagation of Failures Into Payload Systems Resulting in Damage or Loss of Payloads, Vehicle, or Crew
Fail-Operational/*Fail-Operational (Reduced)*/ Fail-Safe	Fail-Operational/Fail-Safe
Emergency-Level Performance With One Module or *a Subsystem* and Portion of Backup Subsystem Inactive	*Electrical Power Subsystem* Designed for Graceful Degradation
Autoswitching and C/W for Time Critical Functions	—

COMPARISON OF SAFETY/RELIABILITY CRITERIA (CONT)

MSP	Power System
Separation or Protection of Redundant Utilities	—
Conservative Factors of Safety for Single-Point Failures	No Single-Failure Points Except Pressure Bottles Which Shall Use Conservative Design Safety Factors

Note: Italics Denote Criteria Not in Agreement

Sources:
(1) 25 kW Power System Projects Requirements Document, DCN 8-1-9-PP-00868, Part IV
(2) MSP Design Guidelines and Criteria, Preliminary

ADVANTAGES AND DISADVANTAGES OF BUILT-IN REDUNDANCY

Advantages	Disadvantages
1. Duration of Failure Protection Extended If Standby Component Not Exposed to Operating Stresses	✓ 1. Built-In Provisions — Higher Weight, Cost, and Complexity
2. Ease of Checkout of Standby Component	2. Fault Detection and Switching Mechanism Introduces Unreliability
3. Efficient Use of Crew Maintenance Capability	
✓ 4. Satisfies Fail-Operational Criteria	

✓ Driving Considerations

VFO674

ADVANTAGES AND DISADVANTAGES OF SPARES/MAINTENANCE

Advantages	Disadvantages
1. A Few Spares Can Back Up Many Items Where Commonality Permits	1. Manned Maintenance Carries Risk of Error
2. Potentially Troublesome Switching Circuits Are Eliminated	2. Special Tools and/or Skills May Be Required
3. Spares Can Be Restocked as Used	3. Inventory Control System May Be Required
4. Failed Equipment Can Be Replaced by Improved Items Rather Than by Duplicates	✓ 4. Disconnects and Means of Isolation Are Required to Allow Replacement, Increased Leakage Paths
✓ 5. System Can Be Restored to Initial Status	✓ 5. Does Not Satisfy Fail-Operational Criteria

✓ Driving Considerations

VFO635

APPROACH TO SAFETY AND RELIABILITY

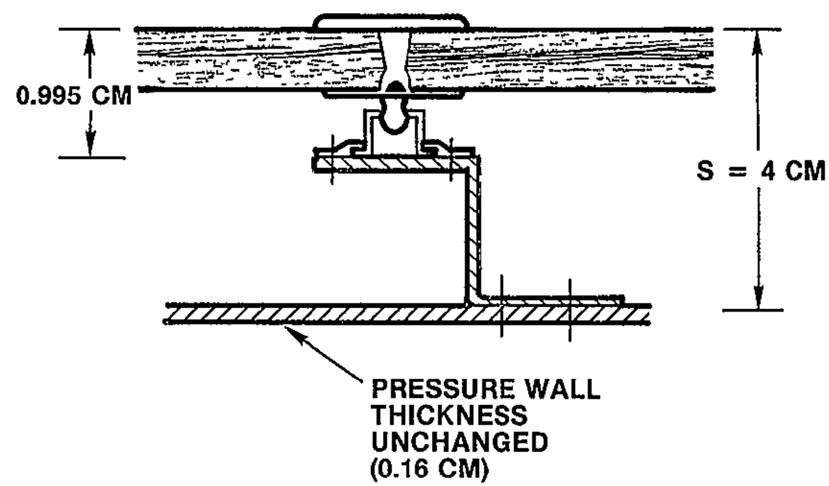
- Built-In Redundancy Where Maintenance Is Difficult or Required for Fail-Operational Criteria

- Maintenance/Spares to Achieve High Statistical Reliability Goals

- Two Separate Subsystems Where Practical for the Two Volumes

SPACELAB METEOROID PROTECTION ANALYSIS

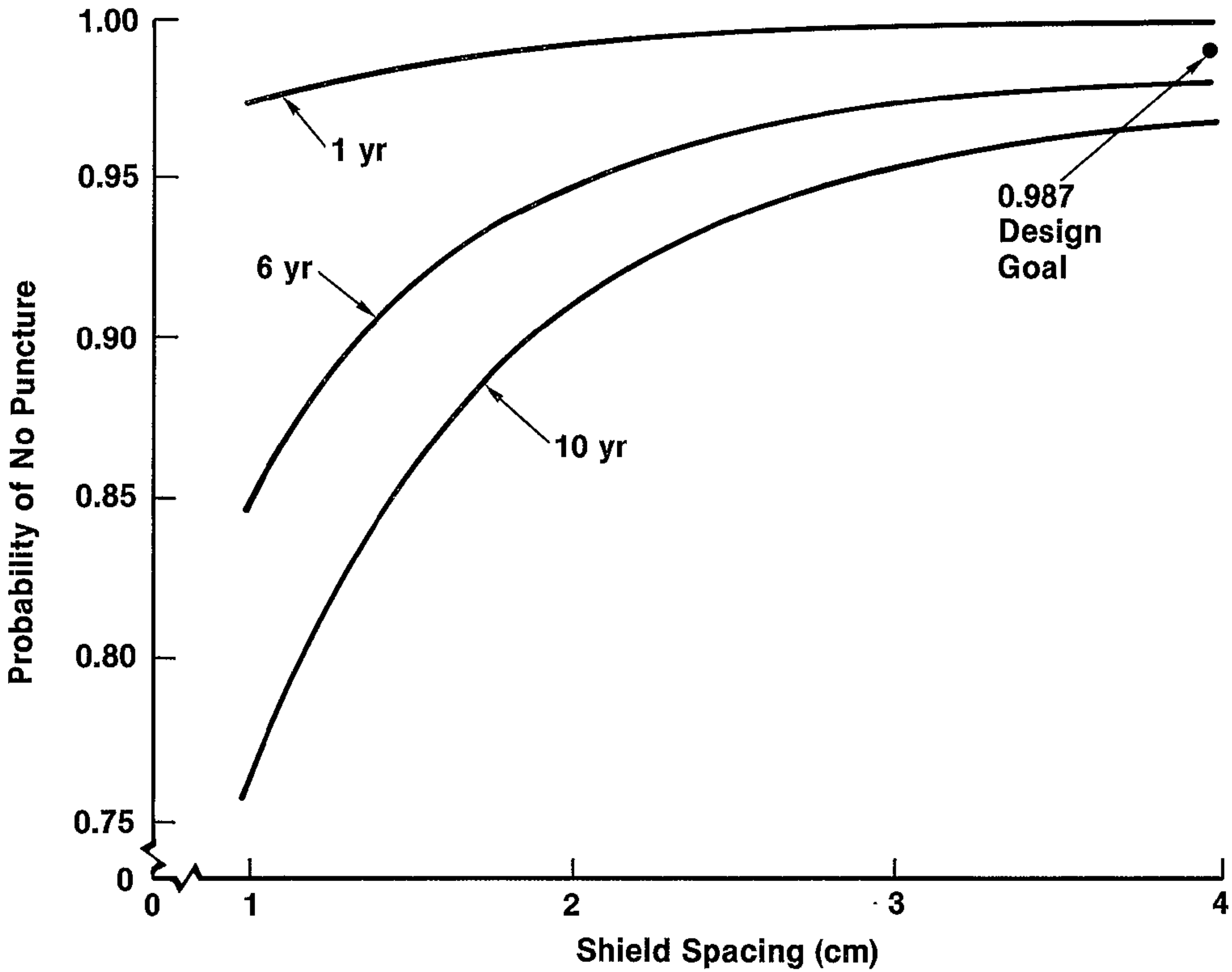
- ERNO-Proposed Configuration
- Spacelab Requirement Is 0.95 Probability for 350 Days
- 0.95 Probability for Four 2-Segment Modules for 10 yr Requires 0.987 Per Module
- Analysis Method According to Burton G. Cour-Palais



MODIFIED SPACELAB WALL

METEOROID PROTECTION ANALYSIS TWO-SEGMENT SPACELAB STRUCTURE

VFO636



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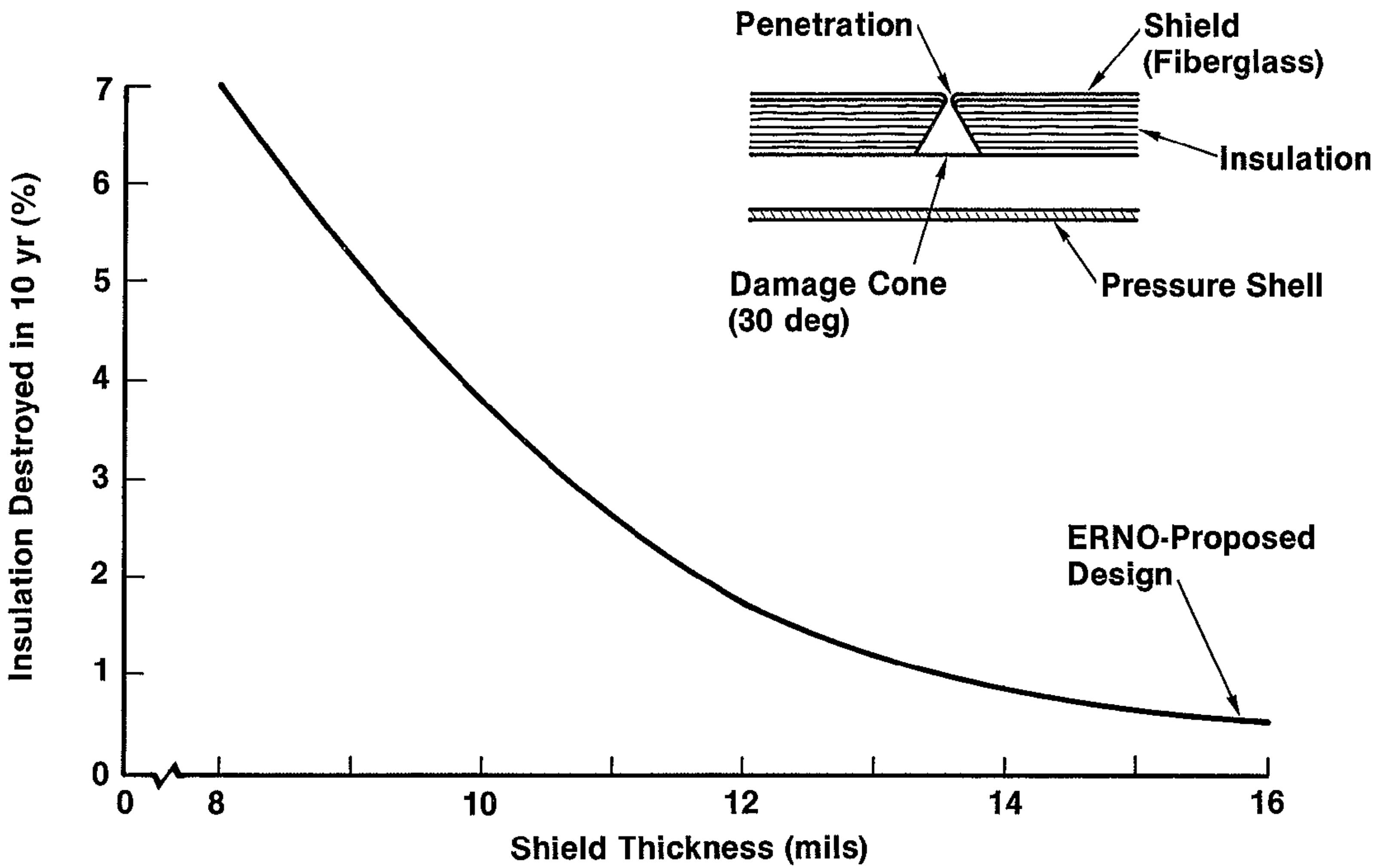
HIGH-PERFORMANCE INSULATION DAMAGE BY METEOROIDS



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SPACELAB METEOROID RESULTS

- MDAC Results Slightly Lower Than ERNO Predictions
  - MDAC — 0.965 Per 2-Segment Module
  - ERNO — 0.987 Per 3-Segment Module
- Greater Shield — Wall Spacing May Be Required
- Test Recommended to Determine Ballistic Limit of Configuration
- Insulation Damage From Meteoroids Not Expected to Be Significant
- Meteoroid Protection Not Considered a Program Driver

PLANNED SUBSYSTEM EFFORT

- Complete Trades
- Detailed Definition – Weight, Power, Volume
- Integrate NASA Comments
- Incorporate ERNO "Medium-Term Study" Results
- Implement Safety/Reliability Approach

AGENDA

Study Overview	Fritz Runge
Special Unmanned Platform Studies (Task A)	
Manned Platform Concept (Task B)	Fritz Runge
■ Configuration, Structural/Mechanical and Operations	
■ System and Payload Requirements, and Performance	Dave Riel
■ Subsystems, Habitability, and Safety	Bill Nelson
■ Programmatics	Denny Niblo

PROGRAMMATICS FOR REFERENCE CONCEPT

VF0809

- Products For Phase C/D Planning
  - WBS and Dictionary
  - Program Schedules
  - Cost Data
  - Facility Requirements
  - Environmental Assessment
- Final Manned Platform Concept Identified End of November

WORK BREAKDOWN STRUCTURE/DICTIONARY

- Submitted Preliminary WBS At First Interim Review
  - MSFC Comments Incorporated
- Completed Preliminary Draft of Dictionary Defining
  - Nonrecurring (DDT&E)
  - Recurring Production
  - Recurring Operations
- WBS Dictionary Baselines DR-6 Organization
  - Review With MSFC

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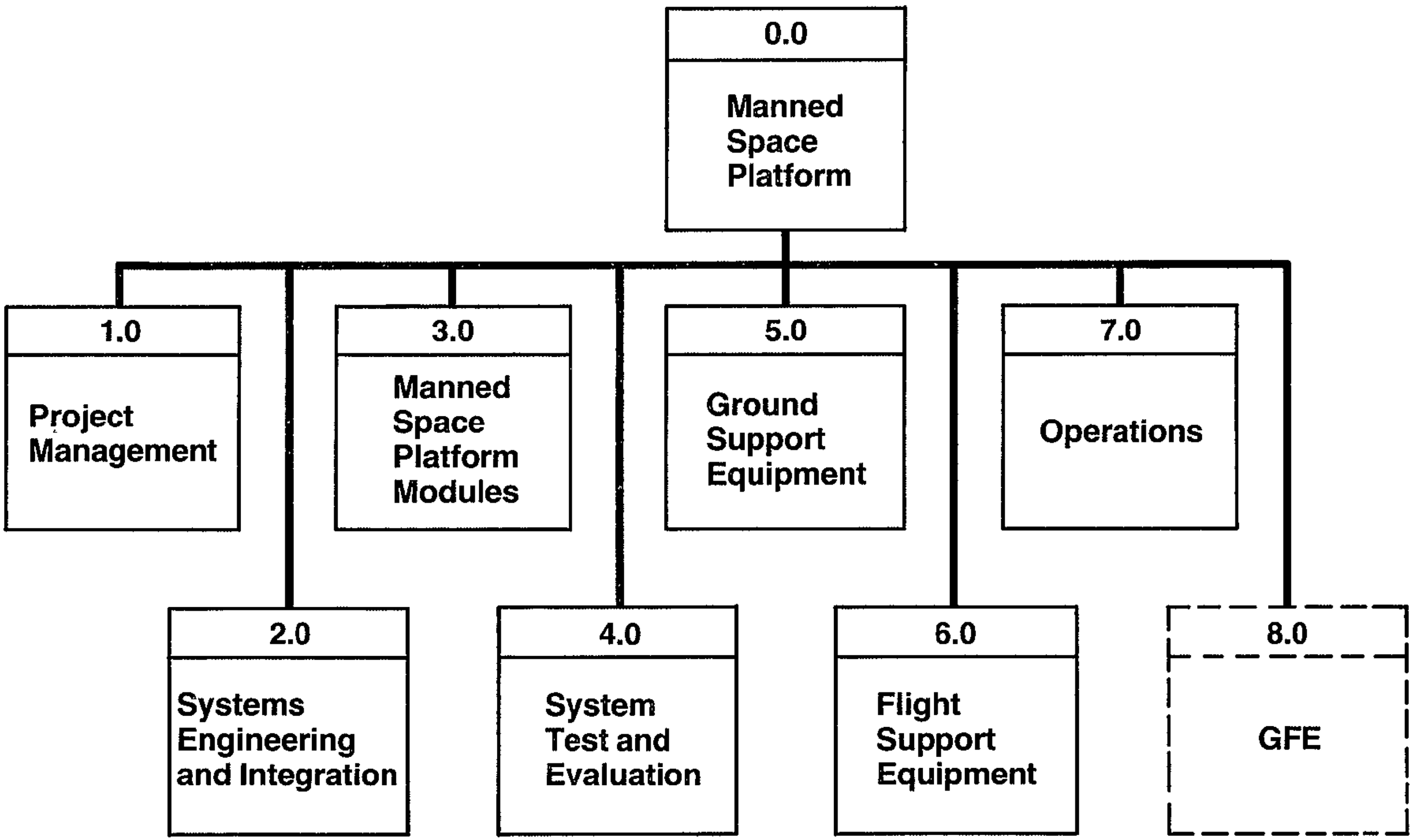
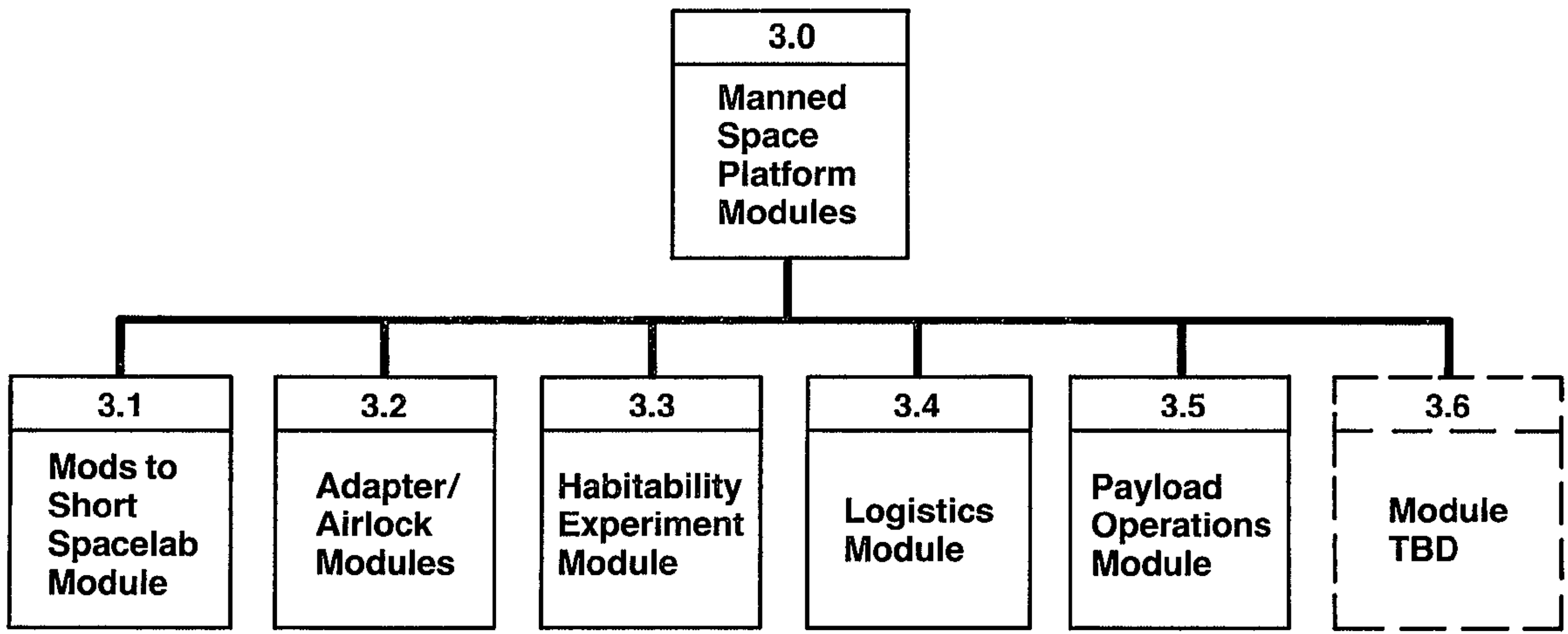
WORK BREAKDOWN STRUCTURE



WBS 3.0
HARDWARE DESIGN/MANUFACTURE



PROGRAM SCHEDULES

Task

- Develop Overall Program Schedules for Phase C/D

Output

- Program Level Schedule
  - Identifies Major Milestones and Events
  - Subsystems Details/Timelines
- Summary Logic Network

Review/Submittal

- Submit Final Schedule Package as Part of DR-4
- Prior Coordination With MSFC

COST DATA

Task

- Develop Phase C/D Cost Estimate for Selected Platform Concept

Format

- Compliant With Requirements of DR-6
- Data Provided for Each WBS Element
- Segregation Among DDT&E, Production, and Operations

Review/Submittal

- Review Format, Estimating Techniques, and Ground Rules With MSFC
- Review Preliminary Data With MSFC Prior to Final Review
- Submit Final DR-6 as Separate Volume of Final Report

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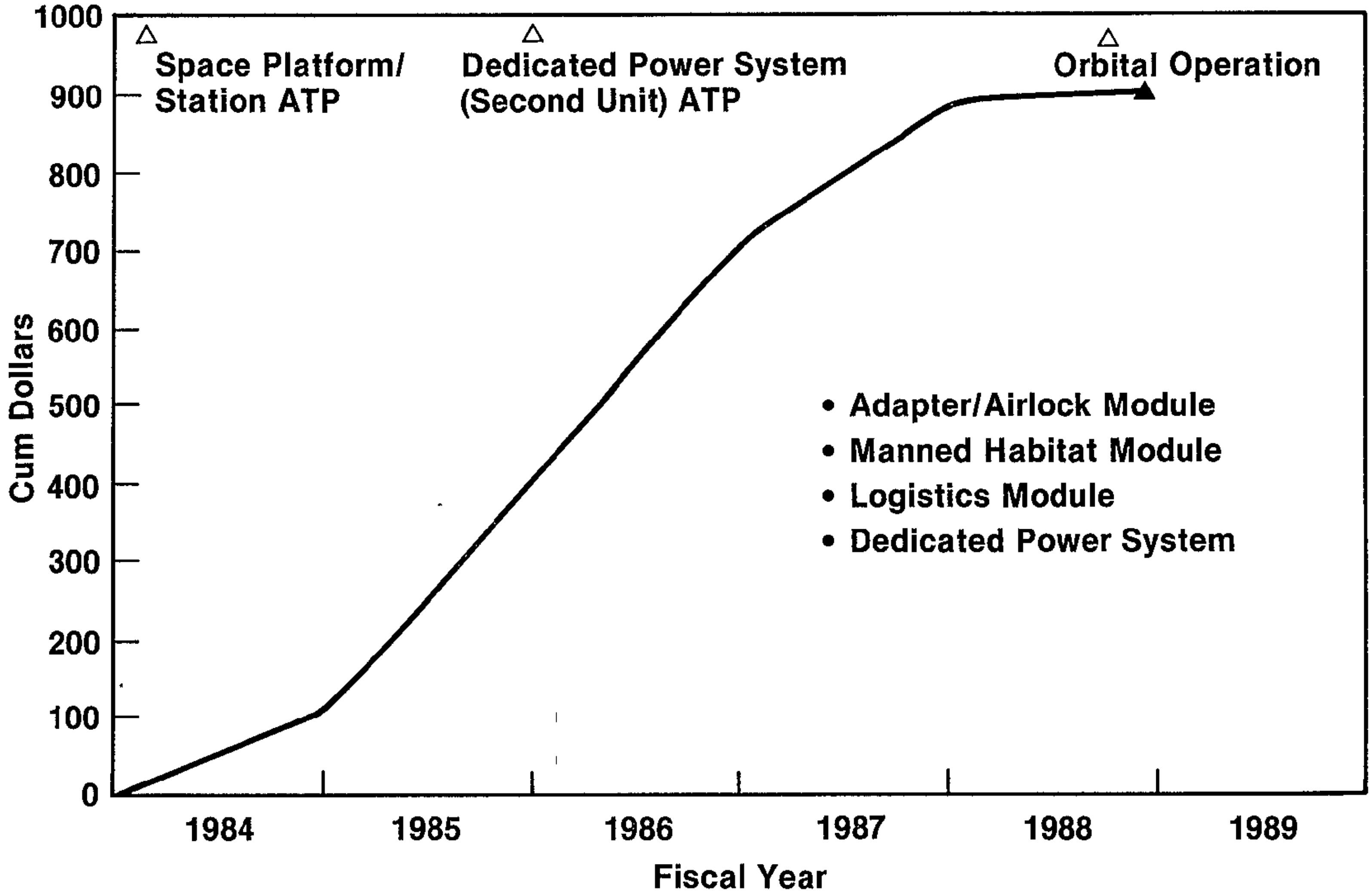
SPACE PLATFORM STATION CONTRACTOR FUNDING PROFILE
(Millions of 1981 Dollars)



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FACILITIES AND ENVIRONMENTAL ASSESSMENT

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Facilities

- Identify New or Unique Requirements
- Identify Major Modifications to Existing Facilities
- Submit Any Impacts as Part of DR-6

Environmental Assessment

- Identify Any Potential Impacts
- Compliant With NHB 8800.11
- Submit as Part of DR-4