DECEMBER 1971

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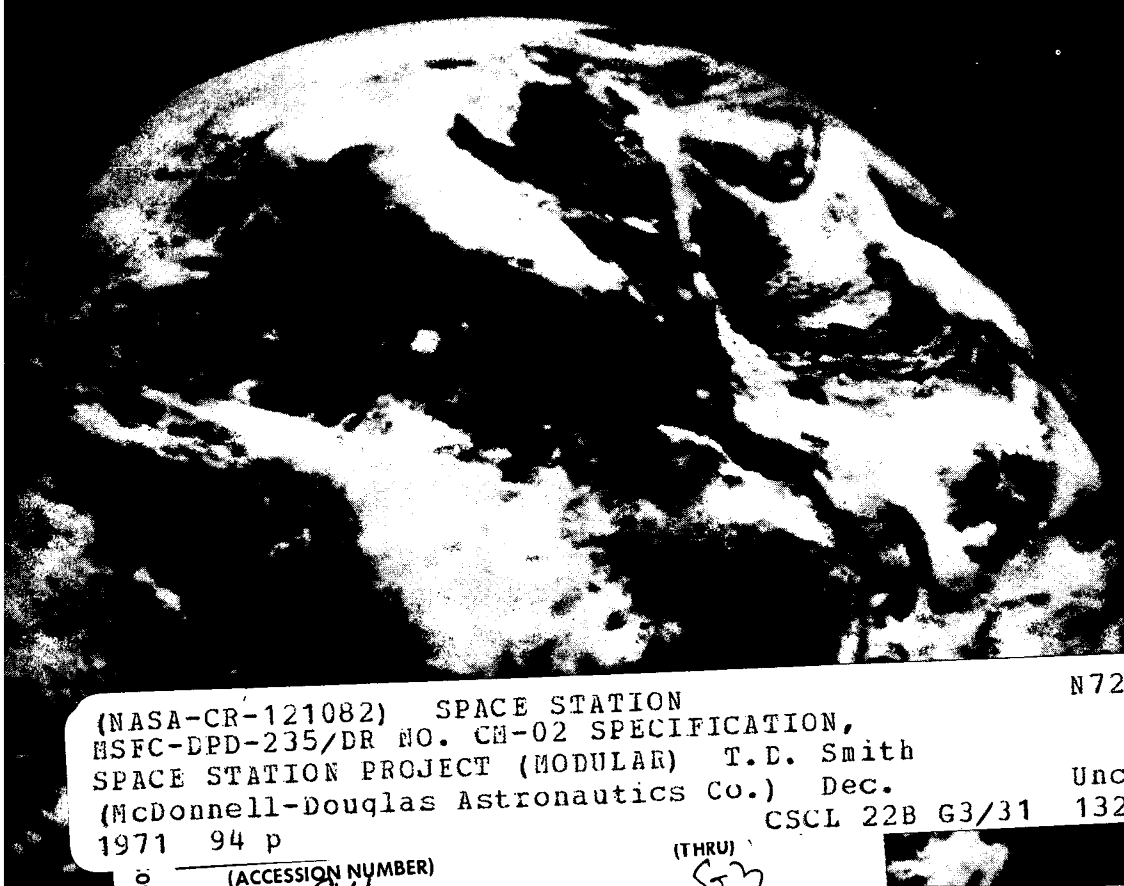
SPACE STATION

MSFC-DPD-235/DR NO. CM-02

SPECIFICATION, SPACE STATION PROJECT (MODULAR)

CONTRACT NAS8-25140



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CONTRACT NAS8-25140
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SPECIFICATION, SPACE STATION PROJECT (MODULAR)

DECEMBER 1971

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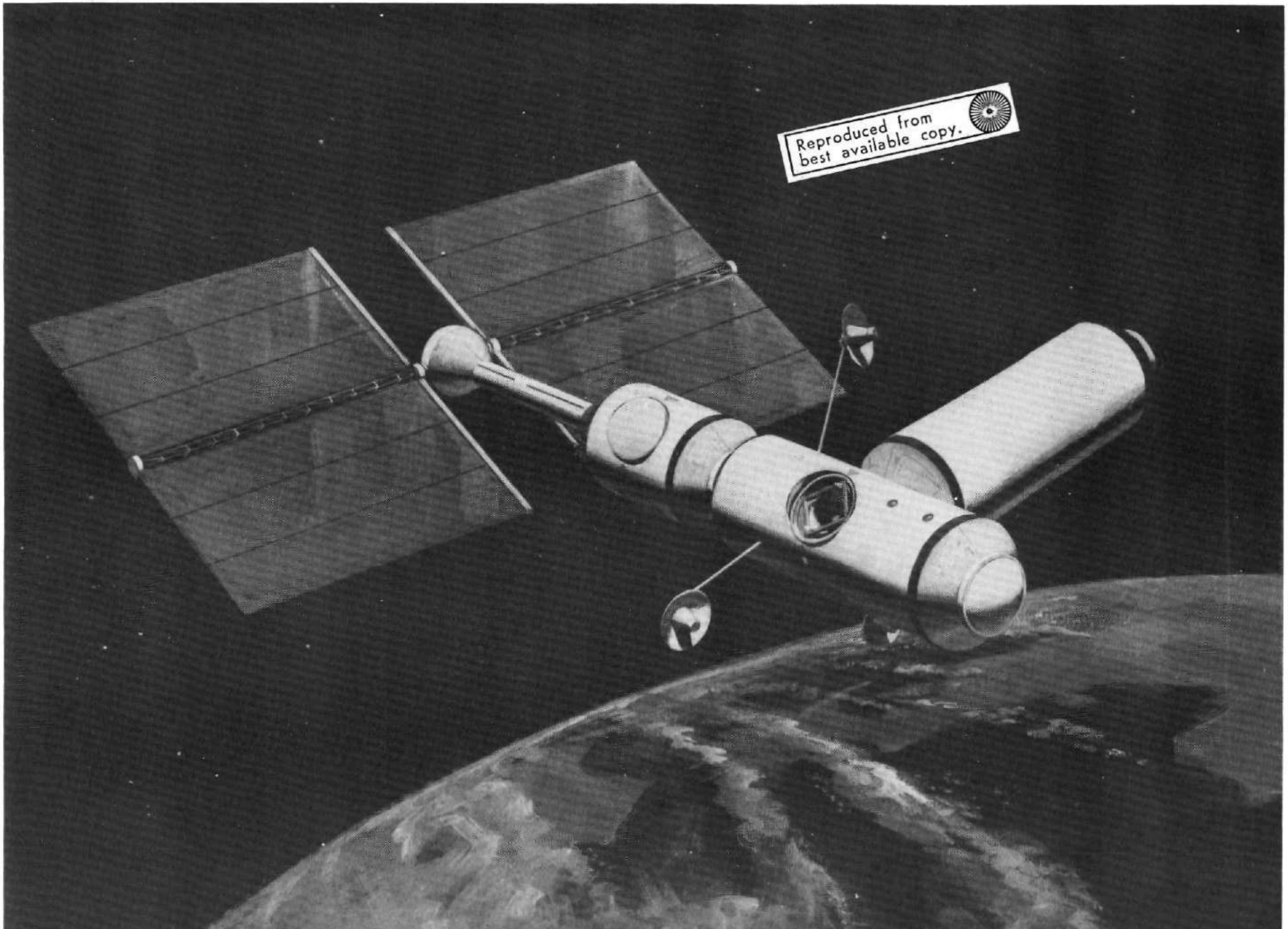

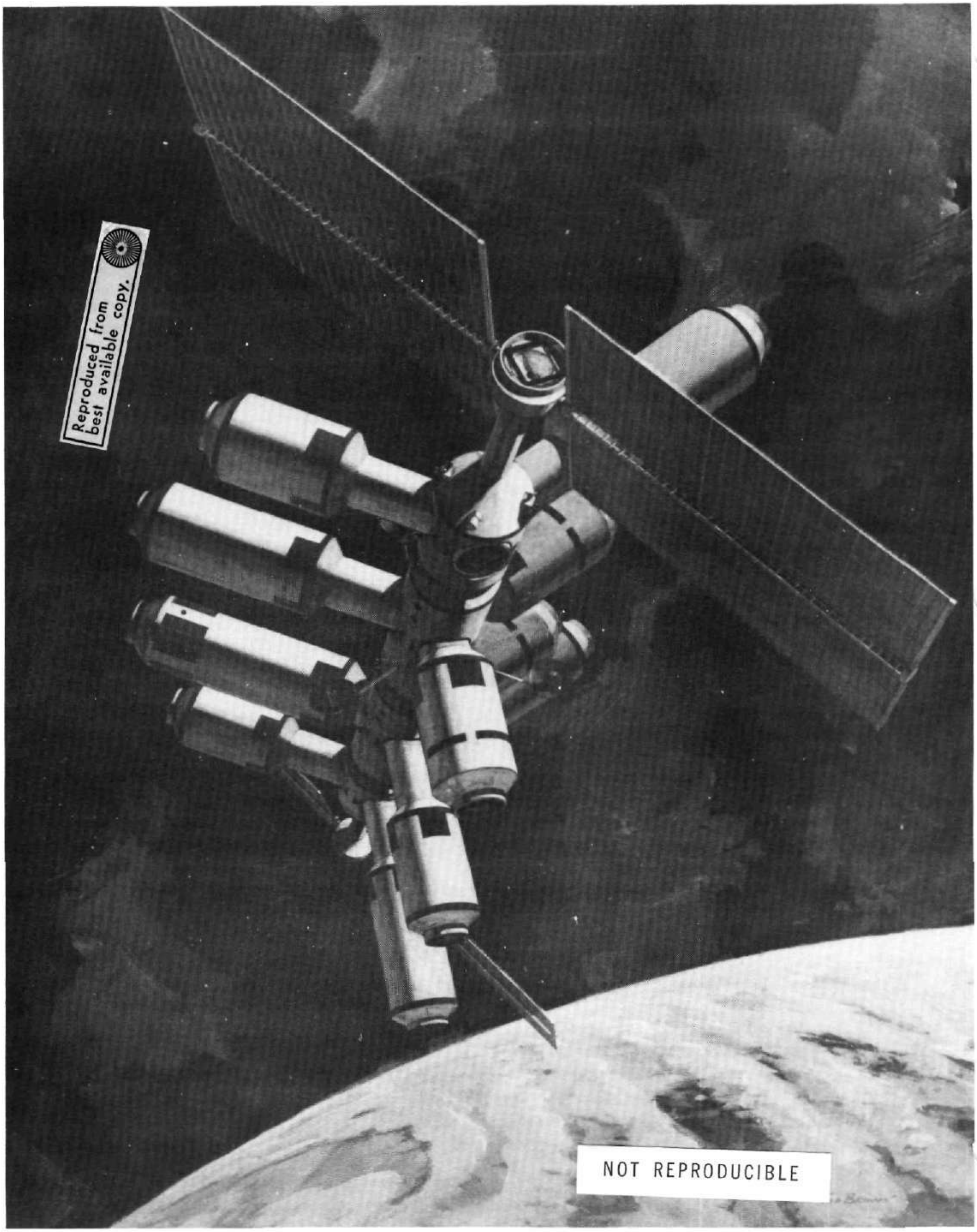

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PREFACE

The work described in this document was performed under the Space Station Phase B Extension Period Study (Contract NAS8-25140). The purpose of the extension period has been to develop the Phase B definition of the Modular Space Station. The modular approach selected during the option period (characterized by low initial cost and incremental manning) was evaluated, requirements were defined, and program definition and preliminary design were accomplished to the depth necessary for a Phase B exit.

The initial 2-1/2-month effort of the extension period was used for analyses of the requirements associated with Modular Space Station Program options. During this time, a baseline, incrementally manned program and attendant experiment program options were derived. In addition, the features of the program that significantly affect initial development and early operating costs were identified, and their impacts on the program were assessed. This assessment, together with a recommended program, was submitted for NASA review and approval on 15 April 1971.

The second phase of the study (15 April to 3 December 1971) consisted of the program definition and preliminary design of the approved Modular Space Station configuration.

A subject reference matrix is included on page v to indicate the relationship of the study tasks to the documentation.

This report is submitted as Data Requirement CM-02.

DATA REQUIREMENTS (DR's)
MSFC-DPD-235/DR NOs.
(contract NAS8-25140)

Category	Designation	DR Number	Title
Configuration Management	CM	CM-01	Space Station Program (Modular) Specification
		CM-02	Space Station Project (Modular) Specification
		CM-03	Modular Space Station Project Part 1 CEI Specification
		CM-04	Interface and Support Requirements Document
Program Management	MA	MA-01	Space Stations Phase B Extension Study Plan
		MA-02	Performance Review Documentation
		MA-03	Letter Progress and Status Report
		MA-04	Executive Summary Report
		MA-05	Phase C/D Program Development Plan
		MA-06	Program Option Summary Report
Manning and Financial	MF	MF-01	Space Station Program (modular) Cost Estimates Document
		MF-02	Financial Management Report
Mission Operations	MP	MP-01	Space Station Program (Modular) Mission Analysis Document
		MP-02	Space Station Program (Modular) Crew Operations Document
		MP-03	Integrated Mission Management Operations Document
System Engineering and Technical Description	SE	SE-01	Modular Space Station Concept
		SE-02	Information Management System Study Results Documentation
		SE-03	Technical Summary
		SE-04	Modular Space Station Detailed Preliminary Design
		SE-06	Crew/Cargo Module Definition Document
		SE-07	Modular Space Station Mass Properties Document
		SE-08	User's Handbook
		SE-10	Supporting Research and Technology Document
		SE-11	Alternate Bay Sizes

FOLDOUT FRAME 1 | FOLDOUT FRAME 2

SUBJECT REFERENCE MATRIX

LEGEND:

- CM Configuration Management
- MA Program Management
- MF Manning and Financial
- MP Mission Operations
- SE System Engineering and Technical Description

	CM				MA		MF	MP			SE								
	CM-01 Space Station Program (Modular) Specification	**CM-02** Space Station Project (Modular) Specification	**CM-03** Modular Space Station Project Part I CEI Spec	**CM-04** Interface and Support Requirement Document	**MA-05** Phase C/D Program Development Plan	**MA-06** Program Option Summary Report	**MF-01** Space Station Program (Modular) Cost Estimates Document	**MP-01** Space Station Program (Modular) Mission Analysis Document	**MP-02** Space Station Program (Modular) Crew Operations Document	**MP-03** Integrated Mission Management Operations Document	**SE-01** Modular Space Station Concept	**SE-02** Information Management System Study Results	**SE-03** Technical Summary	**SE-04** Modular SS Detailed Preliminary Design	**SE-06** Crew/Cargo Module Definition Document	**SE-07** Modular Space Station Mass Properties Document	**SE-08** User's Handbook	**SE-10** Supporting Research and Technology	**SE-11** Alternate Bay Sizes
2.0 Contractor Tasks																			
2.1 Develop Study Plan and Review Past Effort (MA-01)																			
2.2 Space Station Program (Modular) Mission Analysis								●											
2.3 Modular Space Station Configuration and Subsystems Definition														●					
2.4 Technical and Cost Tradeoff Studies							●												
2.4.4 Modular Space Station Option Summary											●								
2.5 Modular Space Station Detailed Preliminary Design														●					
Mass Properties																●			
2.6 Crew Operational Analysis									●										
2.7 Crew Cargo Module															●				
Mass Properties																●			
2.8 Integrated Mission Management Operations										●									
2.9 Hardware Commonality Assessment													●						
2.10 Program Support					●														
2.11 Requirements Definition																			
Space Station Program (Modular)	●																		
Space Station Project (Modular)		●																	
Modular Space Station Project—Part 1 CEI			●																
Interface and Support Requirements				●															
2.12 Plans					●														
2.13 Costs and Schedules							●												
2.14 Special Emphasis Task Information Management (IMS)												●							
Modular Space Station Mass Properties																●			
User's Handbook																	●		
Supporting Research and Technology																		●	
Technical Summary													●						
MOD 29																			●
MOD 40						●													

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Section 1

INTRODUCTION

1.1 BACKGROUND

With the advent of the Space Shuttle in the late 1970's, providing a low-cost means for inserting large payloads into various Earth orbits, a long-term manned scientific laboratory in Earth orbit will become feasible. Using the shuttle for orbital buildup, logistics delivery, and return of scientific data, this laboratory will provide many advantages to the scientific community and will make available to the United States a platform for application to the solution of national problems such as ecology research, weather observation and prediction, and research in medicine and the life sciences. It will be ideally situated for Earth and space observation, and its location above the atmosphere will be of great benefit to the field of astronomy.

This orbiting laboratory can take many forms and can be configured to house a crew of up to 12 men. The initial study of the 33-foot-diameter Space Station, launched by the Saturn INT-21 and supporting a complement of 12 crewmen, has been completed to a Phase B level and documented in the DRL-160 series. Recently completed studies are centered around a Modular Space Station comprised of smaller, shuttle-launched modules. These modules could ultimately be configured to provide for a crew of the same size as envisioned for the 33-foot-diameter Space Station—but buildup would be gradual, beginning with a small initial crew and progressing toward greater capability by adding modules and crewmen on a flexible schedule.

The Modular Space Station conceptual analyses are documented in the DRL-231 series. Recent Modular Space Station Phase B study results are documented in the DPD-235 series, of which this is a volume.

The Space Station will provide laboratory areas which, like similar facilities on Earth, will be designed for flexible, efficient changeover as research and experimental programs proceed. Provisions will be included for such functions as data processing and evaluation, astronomy support, and test and calibration of optics. Zero gravity, which is desirable for the conduct of experiments, will be the normal mode of operation. In addition to experiments carried out within the station, the laboratories will support operation of experiments in separate modules that are either docked to the Space Station or free-flying.

Following launch and activation, Space Station operations will be largely autonomous, and an extensive ground support complex will be unnecessary. Ground activities will ordinarily be limited to long-range planning, control of logistics, and support of the experiment program.

The Initial Space Station (ISS) will be delivered to orbit by three Space Shuttle launches and will be assembled in space. A crew in the Shuttle orbiter will accompany the modules to assemble them and check interfacing functions.

ISS resupply and crew rotation will be carried out via round-trip Shuttle flights using Logistics Modules (Log M's) for transport and on-orbit storage of cargo. Of the four Log M's required, one will remain on orbit at all times.

Experiment modules will be delivered to the Space Station by the Shuttle as required by the experiment program. On return flights, the Shuttle will transport data from the experiment program, returning crewmen, and wastes.

The ISS configuration rendering is shown in the frontispiece. The Power/Subsystems Module will be launched first, followed at 30-day intervals by the Crew/Operations Module and the General Purpose Laboratory (GPL) Module. This configuration will provide for a crew of six. Subsequently, two additional modules (duplicate Crew/Operations and Power/Subsystems Modules) will be mated to the ISS to form the Growth Space Station (GSS) (frontispiece), which will house a crew of 12 and provide a capability equivalent to the 33-foot INT-21-launched Space Station. GSS logistics support will use a Crew Cargo Module capable of transporting a crew of six.

During ISS operations, a total of five Research Applications Modules (RAM's) will be attached to the Space Station for various intervals. Three of these will be returned prior to completion of the GSS. During GSS operations, 12 additional RAM's will augment the two remaining from the ISS phase. Three of the RAM's delivered to the GSS will be free-flying modules. The GSS has the capability for accommodating as many as ten RAM's simultaneously.

During the baseline 10-year program, the Space Station will be serviced by Shuttle-supported Logistics Module or Crew Cargo Module flights.

1.2 SCOPE OF THIS VOLUME

The Program, Project, CEI Specifications, and Interface Support Requirements Documentation, the major output of Phase B, constitute the baseline for all Phase C/D activities and thus Space Station Program development. As shown by Figure 1-1, these specifications have resulted from the orderly development and allocation of requirements which are concise statements of performance or constraints on performance. Guidelines, established by NASA Headquarters, formed the basis for program definition and are identifiable as asterisked paragraphs within the appropriate specifications. This definition was evaluated and further expanded by a systematic development of requirements and collected in Sections 3.1 through 3.5. As this process continued, requirements that affected an interface with other programs were identified in Section 3.6; and requirements which are to be accomplished by a program element (i.e., project) were allocated to that element through Section 3.7. The methods of verifying compliance with these requirements are set forth in Section 4 of the specification.

The requirements identified in Section 3.7 of the Program Specification formed the basis for project definition as the Headquarters Guidelines did for program definition. These requirements were further evaluated and expanded resulting in the allocation of requirements to project elements (i.e., system or CEI) and their interfaces. In a like manner, Section 3.7 of the Project Specification contains those allocated requirements which define system or CEI functional performance. These are in turn were evaluated and expanded in each CEI Specification, Part I. Requirements for the

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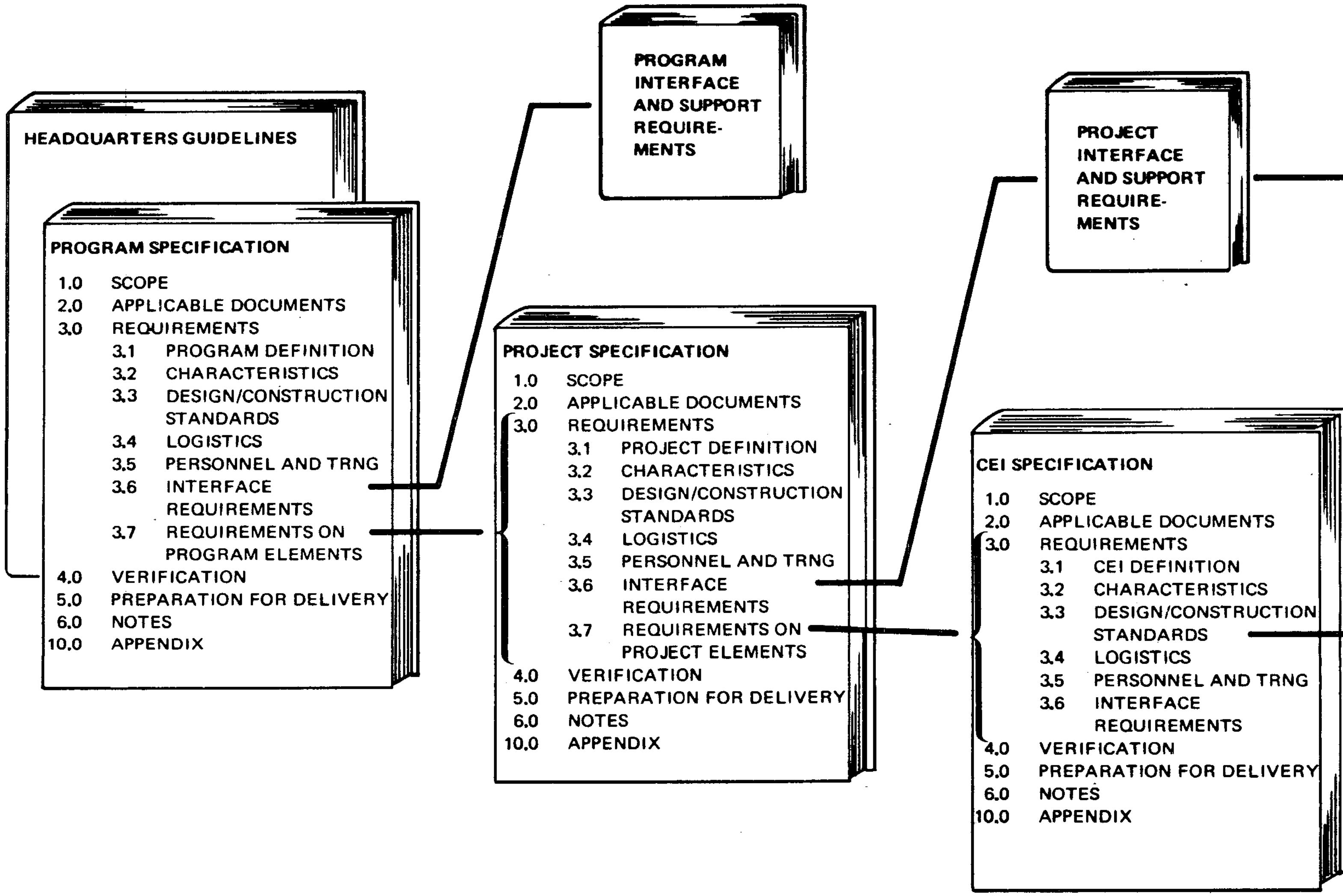

Figure 1-1. Specification Relationships

verification of design solutions compliance are established in Section 4 of both project and CEI Specifications.

The development and structuring of requirements is vital to the interrelationship of management analyses and controls and performance measurement at various management levels and thus warrants a joint contractor-customer responsibility for the process. The Performance Requirements Document (PRD) was an evolutionary document updated by the Phase B Study Contractor, but under MSFC control, which contains all identifiable Space Station Program (Modular), project and system requirements that are defined at any point in time during the study.

This volume contains all requirements identified for the Modular Space Station Project. Other requirements are contained in:

- CM-01 Space Station (Modular) Program Specification
- CM-03 CEI Specifications
- CM-04 Interface and Support Requirements

Figure 1-2 illustrates the specification hierarchy and the various levels of Interface Requirements for the Space Station Program (Modular).

1.3 GLOSSARY OF TERMS

ISS	Initial Space Station
CEI	Contract End Item
GSS	Growth Space Station
WBS	Work Breakdown Structure
FM	Functional Model
FIT	Flight Integration Tool
PRR	Preliminary Requirement Review
PDR	Preliminary Design Review
RAM	Research and Application Module
CPCEI	Computer Program Contract End Item
CDR	Critical Design Review
CPC	Computer Program Component
FACI	First Article Configuration Inspection
PPP	Phased Planning Project
FM	Functional Model

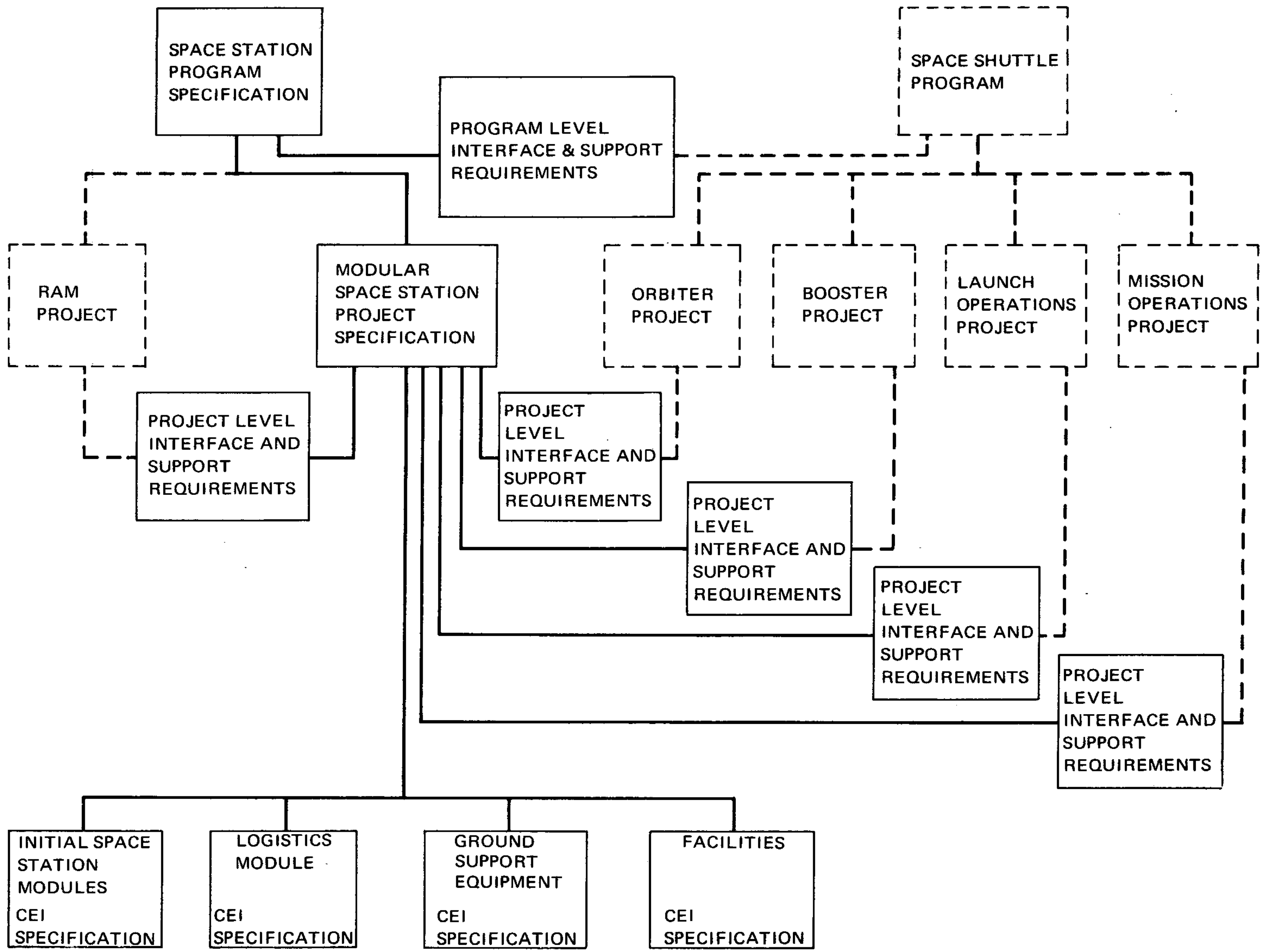

Figure 1-2. Space Station Program Specification Hierarchy

ICD	Interface Control Document
ER	Engineering Release
CMG	Control Moment Gyro
CH&P	Crew Habitability and Protection
GPL	General Purpose Laboratory
KSC	Kennedy Space Center
CDRL	Contract Data Requirements List
MSFN	Manned Space Flight Network
OCS	Onboard Checkout System
CIF	Central Instrumentation Facility
MSOB	Manned Spacecraft Operations Building
TDRSS	Tracking Data Relay Satellite System
DRS	Data Relay Satellite
ETR	Eastern Test Range
GBL	Government Bill of Lading
BOD	Beneficial Occupancy Date
FCEI	Facility Contract End Item
LV	Launch Vehicle
GOWG	Ground Operations Working Group
FMEA	Failure Mode, Effect Analysis
I&SR	Interface and Support Requirements
CII	Configuration Identification Index
CSAR	Configuration Status Accounting Report
DRD	Data Requirement Description
IMM	Integrated Mission Management
JOA	Joint Operating Agreement
JOP	Joint Operation Procedures
TWG	Test Working Group
GSI	Government Source Inspection
MRB	Material Review Board
COQ	Certification of Quality
FMEA	Failure Mode and Effect Analysis

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Specification Number RS02927
Date 10 December 1971

PROJECT SPECIFICATION

PERFORMANCE, DESIGN AND VERIFICATION REQUIREMENTS

FOR THE

MODULAR SPACE STATION PROJECT

Approved By: T. D. Smith

Date:

Approved By: W. Brooksbank

Date:

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Specification No. RS02927
Date 10 December 1971

PROJECT SPECIFICATION

OUTLINE

1. SCOPE

This specification defines the performance, design and verification requirements for the Modular Space Station Project as defined by the Modular Space Station Program Development Plan. All elements and contract end items of Modular Space Station Project shall conform to these requirements. All requirements shall be fully reflected in subsidiary specification.

2. APPLICABLE DOCUMENTS

The following documents, of the exact issue shown, form a part of this specification to the extent specified herein. In the event of conflict between documents referenced, and other detailed contents of this specification, the detailed requirements herein shall be considered superseding.

SPECIFICATION	Text Reference
Federal	
MSFC-SPEC-101B, Flammability, Odor, and Outgassing Requirements and Test Procedures for Materials in Environments Which Support Combustion, March 15, 1971	3.3.2.2.1,
MSFC-SPEC-250, Protective Finishes for Space Vehicle Structures, February 1964	3.3.9
MSFC-SPEC-491, Space Vehicle Ordnance Systems, January 1970	3.3.2.2.4
Military	
MIL-E-6051D, Electromagnetic Compatibility Requirements, System, dated 7 September 1967, and Amendment 1, dated 5 July 1968	3.3.5

STANDARDS

Federal

Military

MIL-STD-143B, Standards and Specifications, Order of Precedence for the Selection of, 12 November 1969	3.3.1
MIL-STD-461A, Electromagnetic Interference Characteristics Requirements for Equipment, August 1, 1968	C.N. #1 C.N. #2 C.N. #3 C.N. #4
MIL-STD-462, Electromagnetic Interference Characteristics, Measurement of, July 31, 1967	C.N. #1 C.N. #2 C.N. #3
MIL-STD-721B, Definition of Effectiveness Terms for Reliability, Maintainability, Human Factors, and Safety, 25 August 1966	3.3.12
MIL-STD-810B, Environment Test Method	3.3.8
MIL-STD-1472A, Human Engineering Design Criteria for Military Systems, 15 May 1970	3.3.15
FED-STD102B, Preservation, Packaging and Packing Levels, January 29, 1963	5.2
MIL-STD-129E, Marking for Shipment and Storage, April 20, 1970	5.3

OTHER PUBLICATIONS

Manuals

MM8040.12, Standard Contractor Configuration Management Requirements MSFC Programs, July 28, 1971	3.3.13
NHB 5300.4 (1A), Reliability Program Provisions	4.1.2.1
NHB 5300.4 (1B), Quality Program Provisions	4.1.1.2.2, 4.1.2.1

OTHER PUBLICATIONS (Continued)

Regulations

U. S. Atomic Energy Commission Title 10 Code of Federal Regulations	3.3.7

Handbooks

MIL-HDBK-5, Metallic Materials and Elements for Aerospace Vehicle Structures	3.3.6
MIL-HDBK-17, Plastics for Flight Vehicles, Part II Transparent Glazing Materials, 14 August 1961	3.3.6
MIL-HDBK-23, Structural Sandwich Composites, 30 December 1968	3.3.6
NHB 7150.1, Reference Earth Orbital Research and Applications Investigations, January 15, 1971	
TMX-53865, Natural Space Environmental Criteria for 1975-1985 for NASA Space Stations, dated August 1970	3.2.1.1.22, 3.2.7.1.1 5.1
TMX-53872, Terrestrial Environmental (Climatic) Criteria Guidelines for Use in Space Vehicle Development, September 8, 1969	3.2.7.1.1, 3.2.7.1.2 5.1
TMX-53957, Space Environmental Criteria Guidelines for Use in Space Vehicle Development, August 26, 1970	3.2.7.1.1
SE-008-001-1, Project Apollo Coordinate System Standard, June 1965	3.3.11.1

DIRECTIVES

OMSF Program Directive M-DMQ 1700.120 Safety Program Directive Number 1 Revision A	3.2.6.1.1

3. REQUIREMENTS

3.1 Project Definition

The Modular Space Station project shall provide the design, (varying configuration and operations) with crew, experiment accommodations, and operational capability to support the Modular Space Station Program. It shall also provide a Logistics Module (LOG M) that will satisfy the operational requirements to transport crew equipment, experiments, spares, fluids, consumables, and the like to and from the Shuttle Orbiter to the Space Station. The LOG M shall remain docked until crew rotation, serve as storage center while docked, and be utilized by the crew and as a storage unit data, equipment etc., for return flight to ground via Shuttle Orbiter.

3.1.1 General Description

* 3.1.1.1 The Space Station Program (Modular) includes the design, development, and operation of a semi-permanent cluster of modules each of which can be transported to and from orbit internal to the Space Shuttle. The Modular Space Station will be capable of growth from and Initial Space Station which minimizes development costs, to a Growth Space Station, equivalent in capability to the zero "g" 12-man, 33-foot diameter configurations defined as of August 1970.

* 3.1.1.2 "Commonality" is a primary consideration throughtout the study. As a goal, common module structures, systems and subsystems and assemblies for Space Station modules, crew cargo modules, and research and applications modules should be developed.

* 3.1.1.3 The Initial Space Station will be operational when fully manned (at least six crewmen), and fully configured including a general purpose laboratory capability in addition to at least two Research and Application modules.

* 3.1.1.4 The Growth Space Station will be sized to accommodate 12 crewmen and will have integral laboratory facilities, research support provisions (power, information management, docking ports, etc.) and habitability provisions equivalent to those provided by the 33-foot diameter designs in the phase B study reported in August 1970.

* 3.1.1.5 The Initial Space Station will utilize subsystems and components that minimize development costs prior to IOC.

3.1.2 <u>Missions</u>

* 3.1.2.1 The Space Station will be capable of use in an orbit of 55 degrees inclination at an altitude between 240 and 270 nautical miles.

* 3.1.2.2 The Growth Space Station will have the capability to accommodate all Blue Book FPE's but not simultaneously.

* 3.1.2.3 The Initial Space Station shall be capable of supporting selected, partial, modified, or combined FPE's from the Blue Book. Blue Book experiments and RAM's are to be scheduled in accordance with station capability. Modified FPE's will require the approval of the NASA.

3.1.3 <u>Operational Concepts</u>

3.1.3.1 General

* 3.1.3.1.1 Total cost of the program is a primary consideration. Primary emphasis is on minimum cost to the IOC.

3.1.3.1.2 The ground support systems for all elements and phases of the mission (prelaunch, launch, orbital, entry, landing, and post-landing operations) shall be designed to minimize operational costs taking full advantage of the onboard systems for checkout, fault isolation, guidance and navigation, programming, and data processing and editing, and of other features providing the Space Station and the Shuttle with a high degree of autonomy.

* 3.1.3.1.3 The development approach will provide the basis for reducing the number and cost of test articles and major tests and will provide for utilization of the Shuttle for on-orbit testing, as required.

3.1.3.1.4 Thermal vacuum testing of a complete program element (Space Station module, cargo module, etc.) shall not be required.

* 3.1.3.1.5 The Space Station will be capable of accommodating a mixed male-female crew.

* 3.1.3.1.6 The Initial Space Station must provide communications with ground networks (such as the MSFN), and other cooperating spacecraft (such as the Shuttle and free-flying experiment modules). These links need not be capable of simultaneous operation. Interruptions as long as 5 hours in communication with the ground network are acceptable.

* 3.1.3.1.7 The Initial Space Station should plan on the use of shared relay satellites to provide nearly continuous access duplex voice links to ground control. The use of a wide band relay satellite should be considered for the Growth Space Station.

3.1.3.1.8 The Principal Investigators will be responsible for the observation associated with their specific areas of investigation, for detailed data analyses and for modifying long-term experiment objectives as required.

3.1.3.1.9 A common time base shall be used by all elements and subsystems within a given element.

3.1.3.1.10 The Space Station Project shall perform the functions of mission planning and flight scheduling for all Space Station project payloads.

3.1.3.1.11 During unmanned phases of operations, a ground based mission operations shall provide ephemeris updates based on ground network tracking data; monitor and support major buildup and activation activities associated with the orbiting vehicle; and maintain the responsibility for final approval of each launch to the Space Station configuration.

3.1.3.1.12 Activation and system operations assessment shall be performed to a predetermined activation plan and approved procedures to establish the operational readiness of the ISS utilizing the on-orbit crew with ground mission support providing technical assistance as required.

3.1.3.1.13 The orbital position and ephemeris data of the Initial Space Station shall be determined by the Ground Network with the Station module configuration providing tracking transponders.

3.1.3.1.14 The orbital position and ephemeris data of the GSS shall be determined on board the Space Station with update to be furnished from the ground at selected intervals.

3.1.3.2 Preflight/Flight Operations

* 3.1.3.2.1 Shuttle launch frequency, to support the Space Station Program will be no greater than one every 30 days.

3.1.3.2.2 Program hardware and test and checkout operation shall be designed so that, where cost-effective, flight hardware will be delivered to the launch site in the ready condition.

* 3.1.3.2.3 Prelaunch and launch operations will be developed so as to require minimum access to the module while in the orbiter cargo bay.

3.1.3.2.4 Space Station modules shall be launched at orbital operating pressure of standard atmosphere (14.7 psia) with no programmed venting. However, overpressure control and emergency venting shall be provided. Systems shall be designed to operate at nominal atmospheric conditions as well as survive pressures of 0.01 mm Hg. Systems are not required to operate at 0.01 mm Hg.

3.1.3.2.5 Space Station systems will be designed with a capability to "hold" for a minimum of (TBD) hours after planned lift-off time, once serviced activated during the countdown.

3.1.3.2.6 The Space Station modules shall utilize ground power until the final portion of countdown and provide the capability for switch-over to internal power without degradation of module performance.

3.1.3.2.7 Common ground facilities shall be available for receiving, loading, buildup, mating and checkout of Modular Space Station Project elements.

3.1.3.2.8 Ground operations policy shall minimize the requirements associated with module checkout, access and/or disassembly at the launch site. Functional checks shall be normally confined to critical functions at the module interface and accomplished through on-board checkout equipment.

3.1.3.2.9 On-pad late-load functions for Logistics Modules shall be scheduled and planned prior to Shuttle fueling.

3.1.3.2.10 Provisions shall be included at all module/Shuttle interfaces which permit monitoring of excessive flight loading, module interior habitability, and safety.

3.1.3.2.11 Support shall be provided on the ground for the duration of the Space Station mission.

3.1.3.2.12 Mission Operations shall provide the capability of activating and commanding on-orbit subsystems for selected operations.

3.1.3.2.13 Logistics Modules and module elements of the ISS shall be designed so that manned access, except for major malfunction or emergency will not be required after mating to the Orbiter and/or on the launch pad.

3.1.3.3 Mission Operations

* 3.1.3.3.1 As a goal, no orientation restrictions will be imposed by subsystems, i.e., electrical power, thermal control, and communications.

* 3.1.3.3.2 Management of long range overall mission planning for the Station will be performed on the ground.

3.1.3.3.3 Management of short term mission planning will be performed by the on-orbit Modular Space Station crew.

3.1.3.3.4 The baseline work day for crew/experimenters shall be 10 hours per day, 6 days per week. Each normal working period shall be scheduled as required within a 12-hour "tour-of-duty" 7 days per week.

3.1.3.3.5 Provisions shall be made for participation of principal investigators (PI's) in the conduct of the experiment under the control of the flight crew.

3.1.3.3.6 For on-orbit operations, no system or subsystem constraints shall be designed into hardware or software that will prohibit either single shift or dual shift operations.

3.1.3.3.7 The Space Station shall have onboard tracking and orbital ephemeris generation capability for detached modules under Space Station control.

3.1.3.3.8 The Space Station shall be capable of operating with a Shuttle and Log M docked to it with reduced Space Station operational capability. The Shuttle will be capable of docking to the Space Station via the Log M. The period of docked operations shall be kept to a minimum.

3.1.3.3.9 During buildup the ISS shall be left in the unmanned mode until the first Logistics Module is attached to the cluster and Space Station life critical and associated emergency functions are operational.

3.1.3.3.10 On-orbit equipment and software shall be designed to allow maximum short-term operational utilization of Space Station resources, by providing an on-orbit scheduling routine capability to integrate those resources and redirect the utiliziation of equipment on a real-time basis.

3.1.3.3.11 During buildup and sustained operations, all unmanned orbital configurations shall provide those subsystem operations (including data, command, and control) necessary to provide for successful manning and activation.

3.1.3.3.12 An on-orbit scheduling technique shall be used to integrate scheduled maintenance of any major subsystem with the experiment operation and maintenance requirements, to minimize operational interference between these activities.

3.1.3.3.13 The Space Station shall not require extensive ground-based monitoring.

3.1.3.3.14 The deactivation of module subsystems for a standby mode shall provide for integral experiments and RAM requirements.

3.1.3.3.15 The Space Station shall perform the docking operations of FFM and maintain the overall management responsibility of docking port assignments, corridors, and clearance for Shuttle/Station terminal docking operations.

3.1.3.3.16 Completed integral experiments with their supplies and spare parts shall be returned from orbit on the first available Space Shuttle flight.

3.1.3.3.17 The Space Station shall provide for a hard Shuttle docking capability via the payload module.

3.1.4 Organizational and Management Relationships

* 3.1.4.1 Space Shuttle guidelines and constraints, level I, will apply to the Modular Space Station unless superseded by the Modular Station guidelines and constraints, level I.

3.1.4.2 A Logistics Module (LOGM) compatible with the Shuttle system is a system within the Space Station project.

3.1.4.3 Work Breakdown Structure Organization

The WBS (Figure 3-1) identifies all major levels and level subdivisions of the Modular Space Station project (ISS phase only). The WBS shall be expanded to designate deliverable end items, subsystems, assemblies, and components. The WBS shall be used to designate appropriate levels at which specifications shall be developed. In conjunction with appropriate top-level shcematics and functional analyses, the WBS shall be used to define operational functions, mission support functions, and essential characteristics of the design.

3.1.4.4 Technical Requirements Structure

The technical requirements structure for ISS is illustrated in Figure 3-2.

3.1.4.5 Software Specifications

Performance Requirements which must be developed for software shall be identified at any appropriate level of specification and detailed in Computer Program Contract End-Item specifications (CPCEI) as defined in MM 8040.12, Exhibit II, Appendix VI. Appropriate interfaces with hardware and other software shall be identified and verification processes shall be designated for the validation of software and its associated interface functions.

3.1.4.6 The Space Station Project (Modular) shall be structured in order to inter-relate the technical requirements structure, Work Breakdown Structure (WBS) and management structure so that they are consistent in regard to leveling and the assignment of authority/responsibilities.

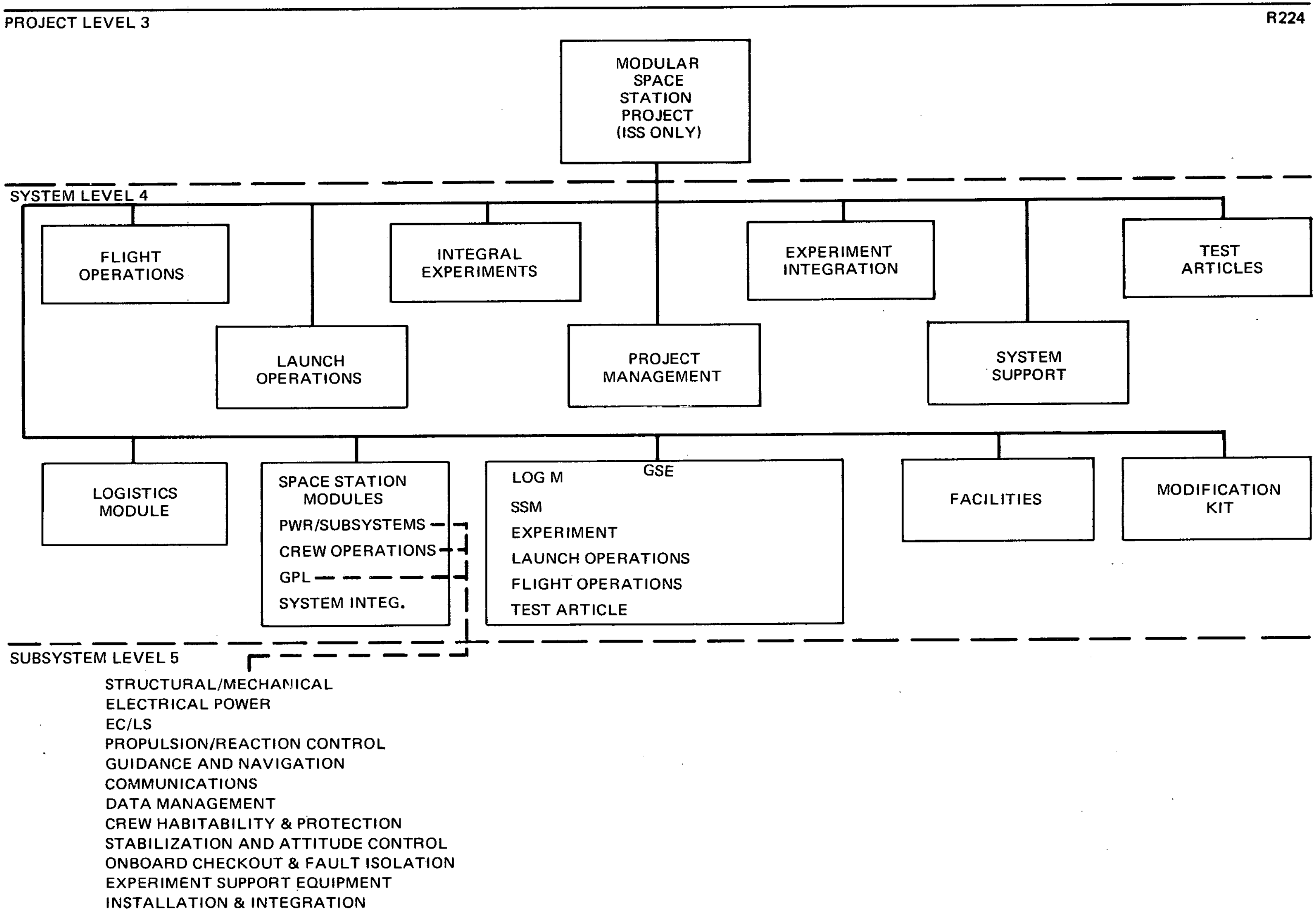

Figure 3-1. Work Breakdown Structure for Modular Space Station Project

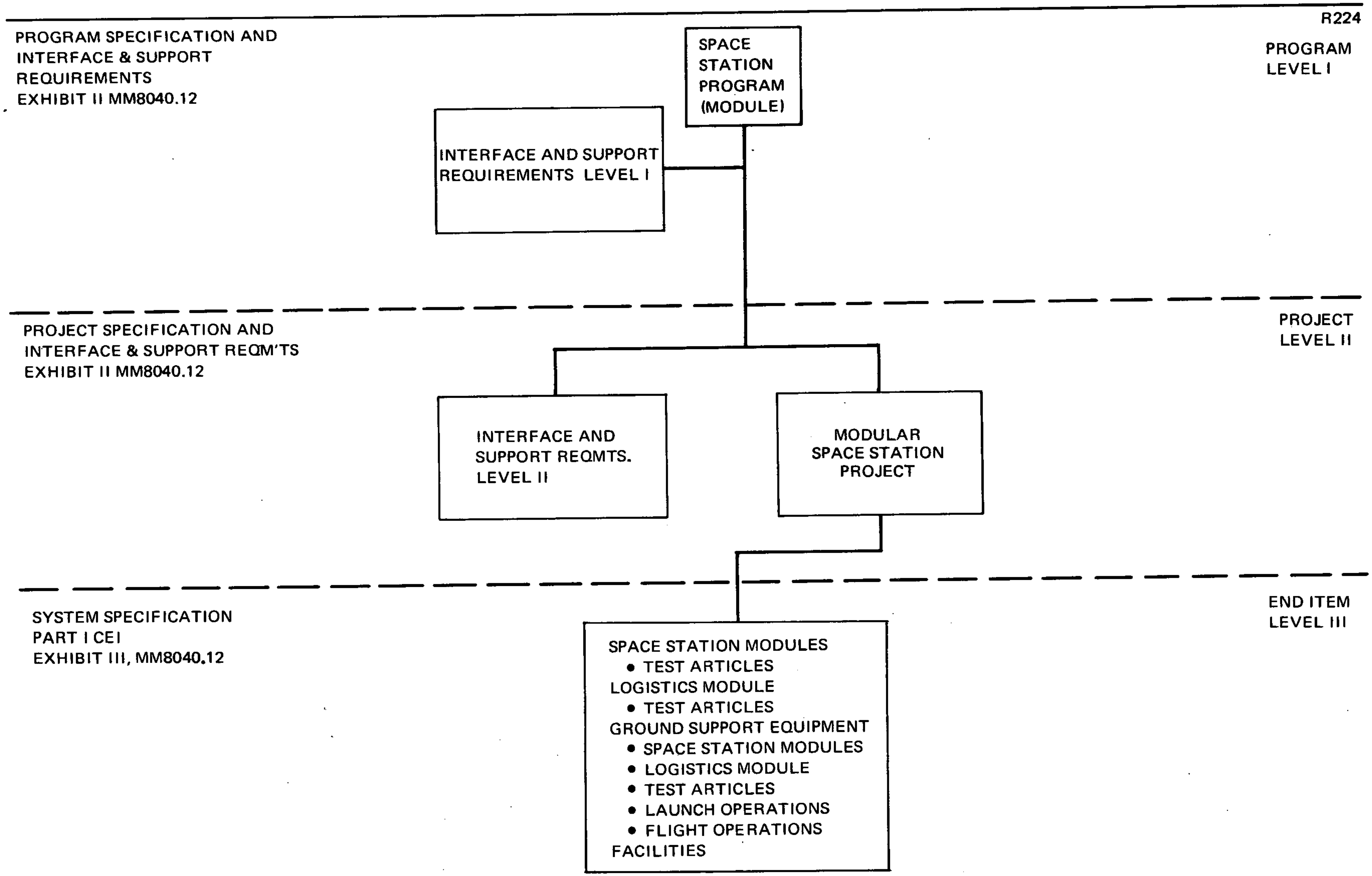

Figure 3-2. Modular Space Station Project Technical Requirements Structure

3.1.5 Systems Engineering Requirements

3.1.5.1 Systems engineering methods shall define the relationships among the various levels of technical requirements, management, cost control and associated schedules.

3.1.5.2 Performance requirements shall be assigned, derived and allocated so that traceability and visibility is maintained from project to end-item specifications.

3.1.5.3 All applicable performance requirements shall be verified and the verification techniques for such requirements shall be established in Section 4 of appropriate specifications.

3.1.5.4 Specification practice and format shall be in accordance with MSFC MM 8040.12 configuration control documentation unless otherwise directed or approved by the contracting agency.

3.1.5.5 Interface and support requirements shall be developed for each level of specification and allocated to permit management control and performance allocations to succeedingly lower levels of development.

3.1.5.6 Systems engineering methods shall provide the necessary planning and implementation processes which expand specifications into appropriate technical and management areas for project development.

3.1.5.7 Systems engineering methods shall be used to define, schedule and control requirements/design reviews and provide techniques for the assessment of design/test results with specified performance at all levels.

3.1.5.8 Systems engineering processes shall be utilized in the expansion and definition of operational concepts.

3.1.5.9 Management responsibilities will be defined and interrelated by level, function and organizational identity.

3.1.6 Government Furnished Property List

None identified

3.1.7 Critical Components

None identified

3.2 Characteristics

3.2.1 Performance

3.2.1.1 Primary Mode

3.2.1.1.1 Illumination shall be provided for docking when needed.

3.2.1.1.2 The Space Station shall maintain a continuous orbital position fix through an outward ephemeris program using periodic state vector updates. Ground tracking data will be used to provide the ISS with periodic state vector updates.

3.2.1.1.3 The Modular Space Station shall provide the orientation control for any combination of modules to accommodate integral and attached module experiment accuracy and orbit-keeping requirements. Horizontal, POP/OR, INERTIAL, VERTICAL, POP, and Solar Orientation shall be provided. The body axis shall be initially aligned to within (TBD) degree and (TBD) degree per second relative to the reference coordinates of the selected orientation. The accuracy required for each orientation is (TBD).

3.2.1.1.4 The crew shall be freed of routine operations to the greatest practical extent by use of automated systems.

3.2.1.1.5 The Space Station shall be designed to have a minimum operational life of 10 years with resupply. The Space Station design shall provide for damage control and repair.

3.2.1.1.6 The EVA and IVA environments shall be free of rough-edged projections or sharp corners that could snag a space suit or cause physical injury. Protrusions (handles, knobs, light fixtures, etc.) shall be recessed or of snag-free design.

3.2.1.1.7 Subsystems shall be designed to incorporate functional product improvements and design growth without change in the interface.

3.2.1.1.8 All subsystems for new program elements shall contain operational instrumentation consistent with system operation and fault isolation and repair to the lowest replaceable unit.

3.2.1.1.9 Space Station information management shall be compatible with all station module derivatives, experiments, RAM's, logistic vehicles, tugs, relay satellite, and ground communication systems.

3.2.1.1.10 System, experiment, and mission status information shall be available onboard, on the ground, or both onboard and on the ground, as required. This information may be processed or raw, and real-time or delayed.

3.2.1.1.11 All docking ports shall be configured to permit mating with any other docking port inherently or with use of a standard adapter kit.

3.2.1.1.12 The Space Station shall provide continuous tracking capability for terminal rendezvous, docking, and other orbital operations.

3.2.1.1.13 All systems that incorporate automated fail/operational capability shall be designed to provide crew notification and data management system cognizance of component malfunction until the anomaly has been corrected.

* 3.2.1.1.14 Onboard systems will be provided for checkout, monitoring, warning, and fault isolation to a level consistent with safety and with the in-orbit maintenance and repair approach selected. Emergency control and repair of failures or damage will also be provided. As a goal, the overall station operations will not be substantially degraded by selected repair modes.

3.2.1.1.15 Automated critical IMS control function shall have a manual or self-check override and interrupt capability.

* 3.2.1.1.16 The Space Station structure and subsystems will be designed for an oxygen/nitrogen mixture at a normal operating pressure of 14.7 psia.

3.2.1.1.17 The Space Station shall have means of producing control torques which are capable of meeting the stabilization and control requirements for all of orbital operations after separation from the Shuttle Orbiter.

3.2.1.1.18 All major load-carrying structure of the structural subsystems shall be designed to a safe life of 10 years in orbit.

3.2.1.1.19 As a goal, fail-safe design concepts shall be applied to all critical structure so that failure of a single structural member shall not degrade the strength or stiffness of the structure to the extent that the crew is in immediate jeopardy.

3.2.1.1.20 The structure shall be designed to resist damage resulting from accidental impact during normal crew activities.

3.2.1.1.21 Orbital Operations requiring manual docking or manual docking capability shall use the following design criteria:

Axial Closing Velocity	1.0 ft/sec
Lateral Velocity	0.25 ft/sec
Pitch, Yaw, and Roll Misalignment	±5.0 deg
Pitch, Yaw, and Roll Rates	0.5 deg/sec
Radial Miss Distance	1.0 ft

3.2.1.1.22 Meteoroid protection shall be provided by the Modular Space Station design so that when exposed to the meteoroid flux given in TMX-53865, Second Edition, dated August 1970, the probability as defined in Sections 3.2.3.3, and 3.2.3.4 shall be achieved.

3.2.1.1.23 Space Station systems which incorporate failure related automatic switch-over controls shall be designed to provide crew notification of the switch-over and confirm proper operation of the system on-line. For critical failures the crew shall be automatically notified of conditions requiring crew attention.

3.2.1.2 Buildup Mode

3.2.1.2.1 The Space Station must be stabilized for initial manning and buildup.

* 3.2.1.2.2 A minimum of two separate pressurized habitable compartments with independent life support capability and provisions and other essential services provided at each manned stage of cluster buildup and operation.

3.2.1.2.3 Full redundant duplex communications capability shall be provided between the activation crewmen and the Shuttle crew.

3.2.1.3 Unmanned Mode

* 3.2.1.3.1 The capability shall be provided for monitoring the Space Station in an unmanned condition to confirm the existence of a habitable environment and the functional capabilities of critical life sustaining subsystems.

3.2.2 Physical

* 3.2.2.1 The "design to" weight of Shuttle transported modules shall not exceed 20,000 pounds.

* 3.2.2.2 The maximum external dimensions of the modules shall be 14 feet in diameter and 58 feet in length. Mechanisms that are external but attached to the module, such as handling rings, attachments for deployment, docking mechanisms, storage fittings, thrusters, etc., shall be contained at launch within an envelope 15 feet in diameter and 60 feet in length.

* 3.2.2.3 The docking port and hatches shall provide a nominal diameter of 5 feet and provide utilizty interfaces with the pressurized volume.

* 3.2.2.4 The Space Station shall have windows arranged to allow both earth and celestial viewing.

3.2.3 Reliability

3.2.3.1 Space Station Project reliability shall provide 10 year useful operational life in which mission objectives can be accomplished. Reliability shall be achieved by using the combination of (1) components selected to minimize wear out and incorporating high inherent reliability, (2) redundancy; and (3) maintenance.

3.2.3.2 Items which require testing for the sole purpose of establishing its reliability shall be justified and approved to NASA prior to incorporation into the design.

3.2.3.3 The probability of not sustaining unrepairable damage to a module shall be at least 0.990 per year for any configuration assembled in orbit.

3.2.3.4 The probability of no loss of pressure in a habitable module shall be 0.90 or greater during the initial 10 years of Space Station operation.

3.2.3.5 When equipment is utilized that has known useful life and reliability parameters, those performance parameters shall be utilized for development of redundancy, maintenance, and inventory requirements. If such data are not available, requirements for redundancy, maintenance, and inventories shall be based on analysis.

3.2.3.6 Single point failures shall be eliminated when practical. When elimination is not practical, safety margins shall be such that the risk and consequences of failure are reduced to an acceptable level.

3.2.3.7 One hundred percent screened electrical/electronic parts shall be utilized unless utilization of unscreened parts is more cost effective, without compromising the reliability of the Space Station.

3.2.3.8 Life-essential and mission-survival equipment shall be maintainable and have active or standby redundancy. Restoration of redundancy after a failure of such equipment shall be given priority over other maintenance or routine operations.

3.2.3.9 Redundant hardware shall be physically separated if possible.

3.2.3.10 Failure detection capability shall be provided for redundant paths down to the level of the lowest individual replaceable item.

3.2.4 Maintainability

* 3.2.4.1 Maintenance and repair will be accomplished on the ground when cost effective. (Space Station Module return will be traded against onboard repair and replacement.)

3.2.4.2 The order of precedence for in-orbit maintenance tasks shall be (1) shirt-sleeve environment, (2) space suit (IVA), (3) space suit (EVA). EVA tasks shall be of an emergency nature only and shall require a case-by-case justification.

3.2.4.3 Refurbishable or replaceable captive fasteners shall be used for all equipment which has planned maintenance capability.

3.2.4.4 Preferential access shall be provided for critical items, items requiring scheduled replacement, and items with high failure risk.

3.2.4.5 Limited life (wear-out items) shall, if noncritical, stay in service until failure; if critical, they shall be installed redundantly or so that a degraded alternate operational mode is available.

3.2.4.6 All walls, bulkheads, hatches and seals whose integrity is required to maintain pressurization shall be accessible for inspection and repair by crewmen in pressurized suits.

3.2.4.7 Replaceable units shall be designed to permit direct visual and physical access by the crew to connectors and couplings for ease of removal or replacement. Precision elements will be provided with suitable guides and locking to aid in replacement.

3.2.4.8 EPS design shall provide for maintenance, repair, or replacement of all normally active electrical modules while in a de-energized state, except for necessary test energization.

3.2.4.9 The design of the pressure shell and other critical structural members shall facilitate maintenance and repair. This includes the use of smooth surfaces, minimization of crevices, and general accessibility.

3.2.4.10 Equipment shall be designed so that replacement/repair can be accomplished by a minimum number of tools. Tools should be multi-use.

3.2.4.11 The Space Station shall provide the capability for inspection and maintenance crews to perform an on-orbit repair mission for the orbiting configuration prior to planned manning.

3.2.5 Operational Availability

* 3.2.5.1 For study purpose the Space Station Program Phase C go-ahead is assumed to be in FY '76. The total program length is not specified. However, the program will provide an identifiable plateau in the Initial Space Station configuration, will reach full Growth Space Station capability six years after launch of the first Initial Space Station module, and will continue Growth Space Station operations for five years.

3.2.5.2 The Space Station shall have the capability to operate in an unmanned mode for 90 days with a 0.90 probability that the station can be restored to the previous operating state. During the unmanned mode only those functions necessary to permit reactivation of the Space Station shall be required.

3.2.5.3 The probability for successful manning and availability for experiment support with maintenance shall be at least 0.97.

3.2.5.4 The Space Station availability (probability of support for a scheduled experiment) shall be at least 0.96 for any manned 120-day period.

3.2.6 Safety

3.2.6.1 General

3.2.6.1.1 Space Station Safety Policies shall be in accordance with OMSF Program Directive M-DMQ 1700.120.

* 3.2.6.1.2 Safety is a mandatory consideration through the total program. As a goal, no single malfunction or credible combination of malfunctions and/or accidents shall result in serious injury to personnel or to crew abandonment of the Space Station.

3.2.6.1.3 All safety hazards shall be identified in order of criticality. Catastrophic or critical hazards shall be eliminated or reduced to controllable or acceptable risk levels.

3.2.6.2 Development

*3.2.6.2.1 The Space Station shall be divided into at least two pressurized habitable volumes so that any damaged module can be isolated as required. Accessible modules will be equipped and provisioned so that the crew can safely continue a degraded mission and take corrective action to either repair or replace the damaged module.

3.2.6.2.2 Sensors shall be installed to provide fire warnings in sensitive or danger areas. Fire-suppressant techniques such as fire extinguishers or automatic isolation and decompression of module compartments shall be provided.

3.2.6.2.3 Visual and audible warning indications for functions presenting an immediate threat to life shall be provided when crewmen are required on-board.

3.2.6.2.4 Redundant equipment and electrical or fluid paths shall be physically separated, where possible, to minimize the probability of damage to one when the other is damaged.

3.2.6.2.5 Emergency lighting shall be provided independent of the prime power systems.

3.2.6.2.6 Pressure hatch design shall provide a means of visual verification that proper closure has been accomplished.

*3.2.6.2.7 Critical onboard subsystems will be designed to minimize risk of loss of modules, injury to the crew or damage to the Shuttle and other interfacing vehicles.

3.2.6.2.8 All components associated with enabling the crew to recognize, isolate, and correct critical system malfunctions must be located onboard and be functionally independent of ground support and external interfaces.

3.2.6.2.9 The design and operation of systems and subsystems in the habitable area shall minimize the generation and preclude harmful concentrations of all gases.

3.2.6.2.10 Safety factors used for structural design shall be consistent with those currently used for manned operations.

3.2.6.2.11 Fatigue criteria shall be based on a load history profile showing usage cycles, load intensities, and environments. Structural members shall be designed to the following factors times that of the maximum expected load history profile.

Low-cycle fatigue = 3.0

High-cycle fatigue = 10.0

3.2.6.2.12 All equipment requiring hazardous operations shall be designed and located to allow direct visual contact between two operators.

3.2.6.3 <u>Initial Manning/Reactivation</u>

3.2.6.3.1 Initial inspections and activation shall be performed by the minimum number of crew (but not less than 2 crewmen) in pressure suits until a safe environment has been established.

3.2.6.4 <u>Crew</u>

*3.2.6.4.1 Two or more suited crewmen will participate in any pressure suit activity and rescue provisions will be provided.

*3.2.6.4.2 The allowable radiation limits for the crew are listed below:

ORGAN	LIMIT DOSE (REM)				
	1-Yr. Avg. Daily	30 Day	Quarterly†	Yearly	Carreer
Skin (0.1 mm)	0.6	75	105	225	1200
Eye (3.0 mm)	0.3	37	52	112	600
Marrow (5.0 cm)	0.2	25	35	75	400

†May be allowed for two consecutive quarters with 6 months restriction from further exposure to maintain yearly limit.

3.2.6.4.3 As a design goal, EVA will be under visual surveillance from the MSS at all times.

3.2.6.5 Orbital Operations

3.2.6.5.1 All modules and spacecraft that are configured to permit occasional or temporary, as well as full time, manned access while docked in the Space Station cluster are required to meet the cluster safety requirements established to assure crew safety during any period of time that they may be manned.

3.2.6.5.2 All modular elements requiring entry by personnel for operation, service, maintenance or repair on-orbit while attached in the Space Station cluster shall be configured and operated to permit two mutually exclusive paths of escape from any credible hazard. Transfer by EVA is acceptable when adequate time and EVA provisions are available.

3.2.6.5.3 Hazardous operations shall be performed under surveillance.

*3.2.6.5.4 Access to an EVA and IVA airlock suit station(s) shall be provided for all credible emergency conditions. Airlock chamber(s) shall be provided to permit crew access for EVA/IVA operations.

3.2.6.5.5 Interfacing systems shall be inactive when connection and disconnection is made. Activation of fluid lines shall be accomplished only when crewmen are a safe distance from the connection.

3.2.6.6 Emergency/Abort

*3.2.6.6.1 Personnel escape routes shall be provided in all hazardous situations. A design goal shall be to provide alternate escape routes that do not terminate into a common module area.

*3.2.6.6.2 Provisions and habitable facilities shall be adequate to sustain the entire crew for a minimum of 96 hours during an emergency situation requiring Shuttle rescue.

3.2.7 Environment

3.2.7.1 Natural

*3.2.7.1.1 Space Station Project flight hardware shall withstand the environments specified in the following NASA documents for a 10-year period with repair, replacement and maintenance as required:

A. NASA Technical Memorandum Report TMX-53865, Second Edition, dated August 1970.

B. NASA Technical Memorandum Report TMX-53872.

C. NASA Technical Memorandum Report TMX-59357, Second Edition, dated August 1970.

3.2.7.1.2 Space Station Project launch support hardware which may be exposed to natural environments shall withstand without adverse effects the environments specified in NASA TMX-53872.

3.2.7.2 Induced

3.2.7.2.1 Structural design of Space Station modules while supported within the orbiter shall withstand the load factors specified below:

	LIMIT LOAD FACTORS (g)		
MISSION PHASE	AXIAL	LATERAL (±)	VERTICAL
Launch	3.0	1.0	1.0
High Q	1.9	1.0	+1.0
End Boost (Booster)	3.3	2.0	2.0
End Boost (Booster)	3.3	0.5	-0.5
Entry	-0.5	1.0	-2.0
Flyback	-0.5	1.0	+1.0, -2.5
Landing	-1.3	0.5	-2.7
Emergency Landing	-8.0 to +1.5	1.5	-4.5 to +2.0

3.2.8 Transportability/Transportation

3.2.8.1 Transportation and handling criteria and policy shall be based on structural characteristics and induced environment criteria utilized in design of operational hardware. Transportation loads shall not exceed operational design loads.

3.2.8.2 The maximum air transportation weight and volume shall not exceed existing air transport capabilities.

3.2.9 Storage

None Identified

3.3 Design and Construction Standards

3.3.1 Selection of Specifications and Standards

All materials, parts, and processes shall be defined by standards and specifications. Standards and specifications shall be selected from Government, industry, and contractor specifications and standards in accordance with MIL-STD-143B. Rationale for the selection of contractor specifications and standards over existing higher order of precedence standards and specifications shall be compiled and maintained for historical record. This rationale shall include an identification of each higher order or precedence specification or standard examined and state why each was unacceptable.

For purposes of this order or precedence, commercial materials, parts and processes shall be considered equivalent to contractor standards.

3.3.2 General

3.3.2.1 Design and construction standards for hardware obtained from the Saturn, Apollo, Gemini, or other Space programs shall be in accordance with existing specifications for those items and in accordance with the standards below, as appropriate. New Space Station Program hardware shall be designed and constructed in accordance with standards in the following sections.

3.3.2.2 <u>Dangerous Materials and Components</u>

3.3.2.2.1 Space Station Program hardware shall be designed in accordance MSFC-SPEC-101B, Amendment 1.

3.3.2.2.2 Where functional requirements preclude meeting flammability requirements, materials may be isolated from the environment by fireproof storage compartments or barrier materials which meet the flammability requirements.

3.3.2.2.3 Materials which offgas, outgas or evolve toxic or noxious products capable of personnel impairment or hazard shall be minimized. If mandatory for operational performance such materials will be isolated by suitable means.

3.3.2.2.4 All ordnance shall conform to the requirements of MSFC-SPEC-491.

3.3.2.2.5 All materials shall be nonflammable when tested in the most oxygen rich environments to which they will be exposed except for food, medical supplies, etc., which shall be stored in fireproof containers at all times unless used or consumed.

3.3.2.2.6 Heat transport fluids located within pressurized crew compartments shall be nontoxic and nonflammable at ambient atmosphere pressure and composition.

*R3.3.2.2.7 All materials selected for use in habitability areas will be nontoxic, nonflammable, and nonexplosive to the maximum extent practical.

3.3.3 Aeronautical

None Identified

3.3.4 Civil

Federal, state, and local codes shall be observed as necessary for construction, fabrication, transportation, communications, and safety.

3.3.5 Electrical

The Space Station Project as a total system shall comply with the requirements of MIL-E-6051D. The Space Station Project as a subsystem of the Space Station Program shall comply with the requirements of MIL-STD-461A and 462.

3.3.6 Mechanical

The structural and mechanical systems shall have sufficient strength and rigidity to sustain yield load without failure, without deformation which would prevent any portion of the vehicle from performing its intended function and without deleterious permanent set. The simultaneous application of accompanying environmental effects (temperature, pressure, slush and vibration) shall be applied to determine the critical loading conditions. These systems shall have sufficient strength and rigidity to withstand the ultimate load without failure and without deformation which would result in premature failure of any safety critical function. Simultaneous application of accompanying environmental effects shall be considered in determining the critical loads. Extremes of the environmental effects with appropriate loads shall be considered. Analysis shall be performed to assess the effects of dynamic magnification, shock factors and surge phenomena as applicable. Design data and materials properties shall be obtained from MIL HDBK 5, MIL HDBK 17, MIL HDBK 23 or alternatively from other sources which meet the approval of the procuring agency.

3.3.6.1 Design Safety Factors

3.3.6.1.1 General Safety Factors:

Yield factor safety = 1.10
Ultimate factor of safety = 1.40

3.3.6.1.2 Cabin, internal pressure only:

Proof pressure = 1.50 x limit pressure
Yield pressure = 1.10 x proof pressure
Ultimate pressure = 2.00 x limit pressure

3.3.6.1.3 Window, internal pressure only:

Proof pressure = 2.00 x limit pressure
Ultimate pressure = 3.00 x limit pressure

3.3.6.1.4 Hydraulic and pneumatic systems, including reservoirs:

Proof pressure = 1.50 x limit pressure
Ultimate pressure = 2.00 x limit pressure

3.3.7 Nuclear

Design practice associated with the containment, handling, and safety of nuclear materials and devices shall comply and be subject to AEC policies and practices defined by Title 10 Code of Federal Regulations.

3.3.8 Moisture and Fungus Resistance

Materials which are not nutrients for fungus shall be used whenever possible. The use of materials which are nutrients for fungus shall not be prohibited in hermetically sealed assemblies and other accepted and qualified uses, such as paper capacitors and treated transformers. If it is necessary to use nutrient materials in other than such qualified applications, these nutrient materials shall be treated by a method which will render the resulting exposed surface fungus resistant. The treated surface must satisfactorily pass the fungus tests in MIL-STD-810B.

3.3.9 Corrosion of Metal Parts

Parts including spares shall be protected against corrosion and stress corrosion. Protective methods and materials for cleaning, surface treatment, and application of finishes and protective coating shall be accomplished in accordance with MSFC-SPEC-250, MSFC-SPEC-106B with Amendment 1, Drawings 50M-02442 and 10M 33107.

3.3.10 Contamination Control

3.3.10.1 No effluents (wastes, propulsion, ventings, material outgassing, etc.) shall deleteriously affect the Space Station, attached modules, adjacent spacecraft, of any of their experiments or measurements. The effects of effluents on the elements shall be minimized by design, including selection of material, outlet locations, direction of flow, sequencing, filtering, or sealing. The resultant effects shall be consistent with the requirements for crew EVA, experiments, optical devices, logistics and ancillary vehicle docking, structures, thermal control, and effective engine performance.

3.3.10.2 Space Station Project Flight hardware shall be designed, manufactured, tested, handled, and operated in such a manner as to assure contamination free operation for critical surfaces or elements

3.3.11 Coordinate Systems

3.3.11.1 The coordinate axes and references planes shall be in accordance with NASA SE-008-001-1.

3.3.12 Interchangeability and Replaceability

Mechanical and electrical interchangeability shall exist between replacement parts, assemblies and subassemblies, regardless of manufacturer or supplier. All parts having the same part number, regardless of source, shall be functionally and dimensionally interchangeable as defined in MIL-STD-721.

3.3.13 Identification and Marking

Equipment, assemblies, and parts shall be marked for identification in accordance with MM 8040.12, Exhibit IV.

3.3.14 Workmanship

Space Station Program hardware, including all parts and accessories shall be constructed and finished in a thoroughly workmanshiplike manner. Particular attention shall be paid to neatness and thoroughness of soldering, wiring, impregnation of coils, markings of parts and assemblies, plating, painting, riveting, machine-screw assemblage, welding and brazing, and freedom of parts from burrs and sharp edges.

3.3.15 Human Performance/Human Engineering

The criteria specified in MIL-STD-1472A shall be met as a minimum in the design of program hardware.

3.4 Logistics

* 3.4.1 The initial Space Station shall have the capacity for independent operation with the full crew for a period of 120 days. This capacity can be included in a cargo module.

* 3.4.2 At least 30 days' consumables, including subsystems and experiments, will be available beyond the scheduled resupply mission.

3.4.3 Ground inventory and storage system shall be provided and controlled in tandem with the on-orbit inventory control.

3.4.4 A capability shall be provided to process cargo on-orbit which shall include:

a. Storage capability to store TBD ft^3 of advanced or unused cargo other than in Log M.

b. Cargo preparation area to receive, inspect, or prepare cargo for return.

c. A system to assist crewmen in the transfer of cargo from module to module.

d. A system to monitor and control cargo inventory and the safe operation of cargo storage and transfer functions.

e. A system capability for the transfer of liquids and fluids from module to module.

3.5 Personnel and Training

3.5.1 The availability of trained manufacturing and quality assurance personnel shall be certified prior to production and training requirements in these areas shall be individually justified.

3.5.2 Flight crew training shall be accomplished under NASA control using various aids including the flight integration tool and associated mission control equipment.

3.5.3 Ground crew training shall be conducted with primary operation ground support equipment (GSE) and facilities.

3.5.4 Ground and flight crew shall have proficiency certified prior to participation in mission operations.

3.5.5 Personnel training and mission simulation shall be provided by utilizing multipurpose hardware where practicable; any additional requirements for training devices shall be identified and justified prior to critical design review (CDR).

3.6 Interface Requirements

3.6.1 Interprogram

3.6.1.1 Modular Space Station Project/Orbiter Project
Reference "RS02928 - Interface and Support Requirements, Modular Space Station Project/Orbiter Project."

3.6.1.2 Modular Space Station Project/Booster Project
Reference "RS02933 - Interface and Support Requirements, Modular Space Station Project/Booster Project."

3.6.1.3 Modular Space Station Project/Launch Operations Project
Reference "RS02934 - Interface and Support Requirements, Modular Space Station Project/Mission Operations Project."

3.6.1.4 Modular Space Station Project/Mission Operation Project
Reference "RS02935 - Interface and Support Requirements Modular Space Station Project/Mission Operations Project."

3.6.2 Intraprogram

3.6.2.1 Modular Space Station Project/RAM Project
Reference "RS02936 - Interface and Support Requirements Modular Space Station Project/RAM Project."

3.6.3 Intraproject

Interface requirements within the Modular Space Station Project when identified will be specified in an Appendix as to this specification. Appendix A contains the ISS Modules to Logistics Modules Interface requirements.

3.7 Requirements for Project Elements

3.7.1 Initial Space Station Modules

3.7.1.1 Mission

3.7.1.2 Operational Concepts

* 3.7.1.2.1 The Initial Space Station will be sized to accommodate at least six crewmen. Provisions for double occupancy will be provided in case they are required during relief crew overlap periods.

* 3.7.1.2.2 There is no requirement that the Initial Space Station configuration accommodate an artificial gravity experiment.

3.7.1.2.3 As a goal, all in-orbit modules shall have the capability of being replaced during buildup and operations with a minimum risk to crew and hardware.

3.7.1.2.4 There shall be a window or windows on the Station to enable visual contact with the Shuttle or free-flying modules during their terminal phases of rendezvous (last 5000 feet) with the station.

3.7.1.2.5 Windows shall be provided at the primary control stations to enable the crew to confirm or control the attitude of the vehicle in a gross manner by reference to the external scene.

3.7.1.2.6 Space Station Modules shall provide capability for observing the external surface of the orbiting configuration.

3.7.1.3 Characteristics

3.7.1.3.1 Environmental Control/Life Support

* 3.7.1.3.1.1 The EC/LS system will provide a shirtsleeve environment with habitable areas for crew activities during the buildup, activation periods, and module replacement period.

* 3.7.1.3.1.2 Carbon dioxide partial pressures will be maintained below 3.0 mm Hg in all habitable areas.

* 3.7.1.3.1.3 The environmental control and life support subsystem shall be designed with a closed wash water loop. Closure of other functional loops will be based on the appropriate trade data.

3.7.1.3.1.4 An active temperature control system shall be provided with external fluid radiators. The cabin temperature will be selectively maintained between 65 and 85°F. The mean radiant wall temperature, referenced to the crew, will be maintained between 60 and 80°F. The maximum surface temperature of surfaces that may be contacted by the crew shall not exceed 105°F. The atmosphere velocity will be maintained, in habitable regions, between 20 and 50 ft/min. The partial pressure of the cabin atmosphere water vapor will nominally be maintained at 8 mm/Hg and shall not exceed 13 mm/Hg. Short transients to 6 mm/Hg will be allowed. No condensation shall form on internal surfaces.

3.7.1.3.1.5 The potability of resupply water must be verified prior to its use on the Space Station. The potability of water used by crewmen will be monitored and controlled.

3.7.1.3.1.6 Atmosphere stores and subsystem capacity sufficient for one repressurization of the largest pressurized habitable volume shall be maintained on the Space Station during manned operations and be available to independently supply any pressurized habitable volume.

* 3.7.1.3.1.7 The atmosphere constituents, including harmful airborne trace contaminants and odors, will be monitored and controlled in each pressurized habitable volume.

3.7.1.3.1.8 The capability shall be provided for breathing pure oxygen before EVA/IVA activity to ensure denitrogenation.

3.7.1.3.2 Electrical System

* 3.7.1.3.2.1 ISS electrical power will be provided by solar arrays. Minimum average load electrical power requirement is 15 Kw at the load bus, averaged over 24 hour period.

3.7.1.3.2.2 As a goal, solar cell arrays shall have a clear unobstructed view of the sun to preclude partial shadowing of their surfaces. If shadowing of the arrays does occur, the arrays shall be designed to provide adequate power during shadowed periods and to preclude shadow-induced damage.

3.7.1.3.2.3 The electrical system shall provide circuit protection devices for all station distribution wiring where necessary.

3.7.1.3.2.4 Standard electrical interfaces shall be provided for power transfer between modules and other attachable elements requiring a power transfer interface with the Space Station Module.

3.7.1.3.2.5 Independent power sources shall be provided for each of the independent pressurizable volumes.

3.7.1.3.2.6 Crew supervisory and maintenance and replacement times and skill requirements for the electrical power system (EPS) shall be minimized by the use of automated or semiautomated monitoring and control techniques.

3.7.1.3.2.7 The EPS selected for the Initial Space Station (ISS) shall accommodate the capability for growth to the Growth Space (GSS) and shall be electrically and physically compatible with the GSS.

3.7.1.3.2.8 The Modular Space Station EPS shall, as a whole, have a maintained lifetime of not less than 10 years; however, elements of the EPS may be replaced in total or in modular form for maintenance or for growth. As a design goal, during this maintenance or uprating period, the required electrical power levels will be sustained without interruption.

3.7.1.3.2.9 The Modular Space Station EPS shall consist of not less than two independent sources, each of which will be capable of supplying backup power for an extended period (TBD) assuming no second failure mode, and full sustaining power for a duration of (TBD) to preserve experiments, instruments, fluid systems, and the like which are required for return to full station operational capability.

3.7.1.3.3 Communications

3.7.1.3.3.1 Modular Space Station communications shall be responsible for providing RF or hardwire data links for the following:

a. Inter and intra module
b. Direct to ground
c. To ground via DRSS
d. With the Shuttle Orbiter
e. EVA functions

3.7.1.3.4 Data Management

3.7.1.3.4.1 The command center shall provide the capability to monitor critical parameters of EVA subsystems.

3.7.1.3.5 Onboard Checkout/Fault Isolation

3.7.1.3.5.1 The Information Management System (IMS) shall provide automatic onboard fault isolation to the replaceable element and automatic onboard malfunction notification of the switchable or controllable element.

3.7.1.3.5.2 Provisions shall be made for detecting, locating, and repairing meteoroid damage.

3.7.1.3.6 Propulsion

3.7.1.3.6.1 Drag makeup impulse shall be provided.

3.7.1.3.7 Guidance and Navigation

3.7.1.3.7.1 Guidance and navigation functions with periodic ground update, shall provide orbital position, orientation and rate information for the total orbital configuration and provide the necessary sensor and signal stimulus for changing orbital status through the stabilization and attitude control and propulsion functions.

3.7.1.3.8 Stabilization/Attitude Control

3.7.1.3.8.1 Stabilization and attitude control functions shall provide capability to maintain or change orbital assembly orientation or attitude. These functions shall operate in conjunction with the guidance and navigation and/or propulsion functions.

3.7.1.3.9 Structures/Mechanical

3.7.1.3.9.1 All hatches shall be capable of operation by one crewman from either side of hatch and a capability for equalization of pressure across the hatch shall be provided.

3.7.1.3.9.2 A minimum of two airlocks, each having a 2-man EVA capability, shall be provided by the Space Station.

3.7.1.3.10 <u>Crew Habitability and Protection</u>

3.7.1.3.10.1 The Space Station module shall contain appropriate provisions and compartmentation for at least the following:

a. Individual Crew Quarters.
b. Wardroom and Recreation Areas.
c. Kitchen.
d. Personal Hygiene and Laundry Facilities.
e. Exercise Area.
f. Dispensary
g. Control Stations.
h. Laboratories and Experiments.
i. Maintenance Shop.
j. Subsystems.
k. Storage of Expendables and Spares.
l. Docking and Cargo Transfer.
m. Airlocks.

3.7.1.3.10.2 Microbiologically and bacteriologically contaminated waste material shall be disinfected as close as possible to its source prior to storage, processing, or disposal. The concentration of bacteria in the atmosphere within each of the pressurized compartments containing crew quarters, process laboratories, or experimental facilities will be monitored and controlled.

* 3.7.1.3.10.3 The Space Station will provide private crew quarters for the nominal crew.

3.7.1.3.10.4 The Space Station shall provide the crew with pleasant and efficient work areas and with comfortable and private living quarters. The layout, furnishings, color schemes, lighting, air conditioning, noise, contamination and odor control, traffic flow provisions, and variety of open and closed spaces will be consistent with good architectural design and decorator practices.

3.7.1.3.10.5 The commander's compartment shall be located for easy access to the primary command and control center.

3.7.1.3.10.6 Microbiological control within the habitable areas will be implemented during prelaunch assembly and maintained throughout the flight regime. Concentrations of microorganisms within habitable areas will be monitored and controlled within acceptable limits, which are (TBD).

3.7.1.3.10.7 There will be windows in the main crew assembly area to provide viewing of the earth and space from the normal space station flight attitude.

3.7.1.3.10.8 Provision shall be made for washing (cleaning) of personnel and equipment in the experiment area where dictated by experiment peculiar requirements.

3.7.1.3.11 Experiment Support

3.7.1.3.11.1 The GPL shall provide standard interfaces for experimental electrical power and data bus. Interfaces for tie-down and cooling will be flexible and adaptable to accommodate a wide variety of carry-on experiments.

3.7.1.3.11.2 The Space Station GPL shall permit easy access to experiment hardware for operation, adjustment, repair, and installation.

3.7.1.3.11.3 Atmospheric isolation capability will be provided for experiments utilizing animals.

3.7.1.3.11.4 Waste management (Including trash stowage, etc.) will be provided to accommodate the disposal of waste products originating from normal station operation.

3.7.1.3.11.5 The Experiment Support Equipment shall have the capabilities to be reconfigured in orbit to accommodate changes in the experiment program.

3.7.1.3.11.6 The Space Station shall have the capability during normal operations of monitoring, activating and deactivating any integral experiment or RAM.

3.7.2 <u>Logistics Module</u>

3.7.2.1 <u>Mission</u>

3.7.2.1.1 A Shuttle transportable module with the capability for transport of cargo and on-orbit storage shall be provided during the ISS phase.

3.7.2.1.2 The Logistics Module shall transport ISS subsystems logistics options during buildup.

3.7.2.1.3 The capability for rescuing a 6 man crew shall be provided.

3.7.2.2 <u>Operational Concepts</u>

3.7.2.2.1 At least one Log M shall remain on orbit at all times after ISS activation.

3.7.2.2.2 After five years, the Log M shall be capable of modification into a Crew Cargo Module for GSS operations.

3.7.2.2.3 The Log M shall provide clear passage for crew transfer between the Space Station and Orbiter.

3.7.2.2.4 The Log M shall provide a refuge compartment during an emergency.

3.7.2.3 Characteristics

None identified

3.7.3 Facilities

3.7.3.1 Mission

None identified

3.7.3.2 Operational Concepts

3.7.3.2.1 All existing ground facilities which can be applied or modified to meet Modular Space Station Project ground operations requirements shall be identified.

3.7.3.3 Characteristics

None identified

3.7.4 Ground Support Equipment

3.7.4.1 Mission

3.7.4.1.1 Ground support equipment shall be identified and verified with the first element of flight equipment it must support.

3.7.4.1.2 All module handling, loading, and transportation shall be compatible with horizontal or vertical orientations and must be within Shuttle constraints for c. g. and reference axes.

3.7.4.1.3 Provisions shall be made for the monitoring and measurement of ground transportation loads which exceed design-to flight loads.

3.7.5 Integral Experiments

3.7.5.1 Mission

None identified

3.7.5.2 Operational Concepts

3.7.5.2.1 Unique experiment waste disposal will be provided as a part of the experiment.

3.7.5.3 Characteristics

None identified

4. VERIFICATION

4.1 General

This section specifies the requirements for verification of each requirement stated in Section 3 of the Modular Space Station Project Specification. Section 4.2 contains the requirements which must be met for verification. The relationship of these requirements to Section 3 and the methods to be used in verification are identified in Section 4.3. The requirements specified herein are limited to the specification of those verification requirements required to implement program level policy in the structuring of a cost-effective test program, and do not address detailed testing requirements as procedures.

4.1.1 Responsibility for Verification

4.1.1.1 Verification Management

4.1.1.1.1 Project

The Project is responsible for the verification of requirements stated in Section 3 in accordance with the requirements specified herein.

4.1.1.1.2 Contractor

A system contractor may be held responsible for the verification of requirements as determined by the project and stated in Section 4.2.

4.1.1.2 Phase Responsibilities

4.1.1.2.1 Development

Development is conducted to verify the feasibility of the design approach and provides the contractor with confidence in the ability of his CEI to pass qualification. Development tests and assessments shall be conducted to obtain empirical data to support the design and development process. As such, the extent of this verification shall be left to the contractor for determination, definition, performance, and supportive documentation. Within the definition, however, the relationship of these activities to the development process shall be described. In those special cases where NASA and the contractor agree that a development test can satisfy the verification requirements of qualification, the development test must comply with all the requirements specified in the qualification criteria.

4.1.1.2.2 Qualification

Qualification shall be performed and documented by the contractor and/or his subcontractor using standard, supportive practices as specified in the Quality Plan. The extent and scope of qualification shall be identified and controlled by NASA/contractor action. Qualification of interproject and project element interfaces and project level operations shall be controlled by the Project through allocated system level requirements.

4.1.1.2.3 Acceptance

Acceptance verification shall be performed and supported by the CEI contractor with complete buy-off documentation such as logs, test history, test results, records of inspection, discrepancies, deficiencies, review board activities and corrective action. These activities shall be performed by the CEI contractor under NASA surveillance to verify that the end item conforms to system performance requirements. NASA shall participate in acceptance to the extent necessary for it to verify that item being accepted has been built in accordance with the qualified design.

4.1.1.2.4 Integrated Systems

Integrated systems performance and support responsibilities for the verification of integrated systems (CEI) performance on the ground reside with the project. Verification of integrated systems shall be performed jointly by NASA and the ISS module contractor using a Flight Integration Tool (FIT).

Each system's office/contractor shall support this activity throughout the integration of its respective system. Specific requirements for the conduct of this verification are contained in Section 4.2 of this document. The verification requirements of each system shall be defined in Section 4.2 of respective CEI specifications.

4.1.1.2.5 Prelaunch Checkout

Each contractor under the cognizance of the respective CEI Managers Office shall be responsible for verifying that the system and ground support equipment are ready to launch and launch support following transport to the launch site. This responsibility may be delegated to a centralized operation at the launch site but definition of requirements and procedures shall reside with the originating CEI Office. The CEI Management office/contractor shall interface with the Space Shuttle Launch Operations Project Office which will be responsible for the integration and overall management of these verifications. These requirements will be stated in the appropriate Interface and Support Requirements documents.

4.1.1.2.6 Flight/Mission Operations

4.1.1.2.6.1 Responsibility for verification that a system will function in its prescribed manner during Orbiter delivery to and from orbit shall reside at the CEI level with support from the respective contractor in its performance and from the Project Office in matters involving the Orbiter interface.

4.1.1.2.6.2 Orbital buildup and operations verification for the project shall be the responsibility of the Project Office with the support of the ISS CEI Manager and the ISS contractor. The requirements for this verification are contained herein for the integrated activities but each CEI specification shall define requirements for the verification of the CEI performance. Thus, each CEI management office and contractor shall support this verification as described in 4.1.1.2.4 herein.

4.1.1.2.7 Post Flight

Post Flight evaluation shall be conducted on all modules, equipment, or experiments returned to Earth from the Space Station either because of failure or planned return. The evaluation is conducted to determine cause of failure or to verify that the item performed in accordance with specification requirements.

4.1.2 Verification Method Selection

Each requirement of Section 3 shall be verified by either assessment or test. Section 4.3 contains a matrix which identifies the method selected for verifying Section 3 requirements and also references the applicable verification requirements which are specified in Section 4.2 herein. This section specifies the criteria for verification method selection to be used by elements of the Modular Space Station Project.

4.1.2.1 Selection Criteria

Using a systems engineering approach, verification requirements are defined based upon criticality categories, design margins and technical parameters and compatible with NHB 5300.4(1A) and NHB 5300.4 (1B). Table 4-1 specifies the verification methods appropriate to each phase and criticality category. Selection of verification method shall be guided by this table and constrained as follows for each technical parameter.

a. Reliability shall be assessed by analytical evaluation of test data acquired for other purposes. No tests shall specifically be designed for verifying reliability without prior NASA approval.

Table 4-1

VERIFICATION METHOD REQUIREMENTS

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TYPES OF HARDWARE \ VERIFICATION METHOD	VERIFICATION PHASES: DEVELOPMENT	QUALIFICATION	ACCEPTANCE	INTEGRATED SYSTEMS	PRE-LAUNCH CHECKOUT	FLIGHT/ MISSION OPERATIONS
	ANALYSIS, DEMONSTRATION, TEST	SIMILARITY, ANALYSIS, INSPECTION, DEMONSTRATION, TEST	ANALYSIS, INSPECTION, DEMONSTRATION, TEST	ANALYSIS, DEMONSTRATION, TEST	INSPECTION, DEMONSTRATION, TEST	ANALYSIS, DEMONSTRATION, TEST
SPACE STATION PECULIAR (INCLUDING INTEGRAL EXPERIMENTS)						
COMPONENT	ALL CATEGORIES	ALL CATEGORIES	ALL CATEGORIES			
ASSEMBLY/SUBSYSTEM	ALL CATEGORIES	ALL CATEGORIES	ALL CATEGORIES			
MODULE	ALL CATEGORIES	ALL CATEGORIES	ALL CATEGORIES		1 & 2	ALL CATEGORIES
SYSTEM	ALL CATEGORIES	ALL CATEGORIES	ALL CATEGORIES	ALL CATEGORIES	1 & 2	ALL CATEGORIES
MODIFIED/EXISTING						
COMPONENT		ALL CATEGORIES	ALL CATEGORIES			
ASSEMBLY/SUBSYSTEM		ALL CATEGORIES	ALL CATEGORIES			
GROUND SUPPORT EQUIPMENT						
COMPONENT	1 & 2	1 & 2				
ASSEMBLY/SUBSYSTEM	ALL CATEGORIES	ALL CATEGORIES				
SYSTEM			ALL CATEGORIES	ALL CATEGORIES		

ALL CATEGORIES   1 & 2

b. Maintainability shall be verified primarily by analysis and demonstration. Only mission critical maintenance tasks may be verified by test.

c. Operational availability requirements shall be verified by the analysis of lower level verification data and demonstration performed in conjunction with integrated systems testing.

d. Physical requirements shall be verified by inspection and/or test.

e. Crew useability shall be verified by demonstration.

f. Hardware that has been used on previous programs shall only be qualified by test for those additional critical environments, properly allowing for interaction of environments and including lifetime when possible.

4.1.2.2 Assessment

When the chosen method of verification is an assessment it shall be performed in accordance with one of the following methods:

4.1.2.2.1 Similarity

Similarity may be used if (1) it can be shown that the article is similar or identical in design and manufacturing process to another article that has been previously qualified to similar criteria, and (2) analysis of dissimilarities either in design, manufacturing process or verification criteria substantiates that the article will perform its intended function within the specified envelope. Similarity shall pertain to characteristics such as material, configuration, and functional element or assembly, and may be applied selectively for applicable environments.

4.1.2.2.2 Analysis

Analytical techniques may be used to verify compliance to specification requirements. The selected techniques shall include system engineering analysis, statistics, qualitative analysis, and computer simulation. Analysis shall not be the sole basis of qualification. Analysis lends itself to the verification of items which require extrapolation from empirical data to prove satisfaction on those requirements that do not warrant the expense of acquiring empirical data.

4.1.2.2.3 Inspection

Inspection shall be used only to verify the construction features, drawing compliance, workmanship, and physical condition of the end item.

4.1.2.2.4 Demonstration

Demonstration shall be used when actual conduct/operation can verify end-item such features as service and access, maintainability, transportability, or human engineering features. This method shall be used in lieu of test.

4.1.2.3 Test

Each test program shall be defined so that testing other than development testing is performed in direct response to a Section 4 requirement and when an acceptable level of confidence cannot be established by any of the above assessment methods or if testing can be shown to be the most cost effective method.

4.1.2.4 Criticality Categories

Criticality categories are established for flight and ground support hardware to provide guidelines for determining the test emphasis consistent with attaining the objectives of mission success and crew safety. This categorization is predicted on the possibility of equipment failures which may be human or equipment induced. The criticality categories are as follows:

Category	
1	Loss of life of crew member(s) (ground or flight).
1S	Applies to safety and hazard monitoring systems. When required to function because of failure in the related primary operations system(s), potential effect of failure is loss of life of crew member(s).
2A	Immediate mission flight termination or unscheduled termination at the next planned earth landing area, including loss of primary mission objectives.
2B	Launch scrub.
3	Launch delay, including loss of secondary mission objectives.
4	None of the above.

4.1.3 Relationship to Management Reviews

NASA will confirm that the requirements for verification specified in Section 4.2 and the methods and phases identified in the Verification Matrix, Section 4.3, are appropriate and provide NASA the assurance of meeting the specified requirements in the most cost effective manner

4.1.3.1 Preliminary Requirements Review (PRR)

4.1.3.1.1 Each Project shall support PRR by presenting verification concepts for review and assurance of overall project compatibility. Development tests required to select or substantiate design approaches shall be of special concern in establishing this baseline.

4.1.3.1.2 The program/project specification shall be approved at the PRR.

4.1.3.2 Preliminary Design Review (PDR)

4.1.3.2.1 PDR for the structure shall occur sufficiently early in Phase C to provide for the design and fabrication of test article hardware to ensure meaningful integration of ISS modules.

4.1.3.2.2 PDR, a formal technical review of the basic design approach, shall include a technical review of the basic verification approach of each CEI and the integration of these systems.

4.1.3.2.3 Test article design and operational concepts shall be reviewed at ISS Module PDR.

4.1.3.2.4 Verification participation in PDR shall include identification of requirements for development testing; preliminary criteria for receiving inspection/test, in-process inspection/test, end-item test and acceptance inspection; and preliminary development and qualification test plans which include the methodology for verifying the design and performance requirements of Section 3.

4.1.3.2.5 Sufficient analyses and testing shall be conducted to provide confidence in the design approach and its producibility.

4.1.3.2.6 The Part I CEI specification listing performance/design requirements and verification methods shall be approved at the PDR.

4.1.3.3 Critical Design Review (CDR)

4.1.3.3.1 The formal technical review of CEI design performed at CDR shall be supported by development verification data.

4.1.3.3.2 As a goal, all development data shall be available by completion of CDR.

4.1.3.3.3 Test review at CDR shall cover analysis of available development and qualification test data, preliminary end-item test plans, sampling plans, and detailed inspection plans.

4.1.3.3.4 Processing and manufacturing methods specified by the design which have not been previously used shall be substantiated prior to release of drawings.

4.1.3.3.5 The Part II CEI specification indicating design solutions and verification requirements shall be presented at the CDR.

4.1.3.4 Configuration Inspection (CI)

The Configuration Inspection is a formal technical review to determine if the end item hardware has been built and verified in accordance with the Part II CEI Specification which is presented at the CI for approval. The CI establishes that verification was performed and that the as-built hardware did in fact comply with the requirement of the Part I CEI Specification. The verification documentation and hardware presented at CI shall verify the applicable portion of Section 4.2 of this program specification.

4.1.3.5 Post-CI Reviews

The status of verification shall be reviewed at each major milestone and documented prior to initiation of the next activity. Management reviews shall be utilized to perform these reviews. As a minimum these reviews shall occur at completion of integrated systems verification, pre-launch checkout, orbital buildup and at the time of a flight article movement.

Specific requirements for these reviews shall be stated herein by completion of PRR.

4.1.4 Test/Equipment Failure

4.1.4.1 Failure/Retest Criteria

4.1.4.1.1 Prior to the performance of any verification, the criteria of failure must be objectively established in procedural documentation.

4.1.4.1.2 Subsequent to each failure, but prior to retest, an evaluation shall be made to determine whether partial test requirements have been met prior to failure or can be met by other means. If either is true, total retest shall not be performed.

4.1.4.1.3 Failures occurring in qualification testing shall disqualify any item with same specifications from similar use.

4.1.4.1.4 After test qualification, a post-test inspection shall be made to identify any potential failure modes.

4.1.4.1.5 Hardware used in unsuccessful tests shall be evaluated as to its further use. If the test was a failure as a result of hardware design or function, identical hardware shall be disqualified from similar uses.

4.1.4.2 Hardware/Computer Program Reuse

4.1.4.2.1 As a goal, all test hardware/computer programs shall be refurbished/recompiled and reused, whenever cost effective, as higher level assembly test hardware or flight spares. In the case of failed hardware/computer programs, failure reports shall be reviewed and a determination made as to the suitability of the item for further use. This determination shall include the specification of reuse leveling (i.e., test hardware or flight spares).

4.2 Phased Verification Requirements

4.2.1 Development

Development assessment and tests are performed to verify the feasibility of the design approach prior to committing to the production of flight hardware.

4.2.1.1 Analysis

4.2.1.1.1 Design and analytical algorithms shall be employed, where possible, to reduce the need for exhaustive and redundant testing.

4.2.1.1.2 Development analysis shall consist of common accepted systems engineering and mathematical methods. The findings of these analyses shall be documented to provide traceability at PDR.

4.2.1.2 Demonstration

4.2.1.2.1 Development demonstrations shall be substantiated at PDR as required for development analysis.

4.2.1.3 Test

4.2.1.3.1 Development tests are conducted to determine optimum design margins, stress effects, failure modes under varied combinations and sequences of environmental stresses, safety parameters, applicability of processes, etc.

4.2.1.3.2 Development hardware shall be representative, but not necessarily identical to, flight hardware or operational GSE.

4.2.2 Qualification

Qualification is performed on hardware identical to the flight article to verify that design and performance specifications have been met. Deviating in hardware or environment identicality shall be identified and rationalized in qualification documentation.

4.2.2.1 Similarity

4.2.2.1.1 Hardware characteristics (all or partially) qualified for use on a previous program may be verified for Space Station use by similarity if the following requirements are met:

a. The manufacturer and fabrication/assembly processes are the same.
b. The environments and/or operating conditions for which it was qualified are equivalent to those required of the Space Station.
c. Any dissimilarities between performance and Space Station requirements can be demonstrated to have a negligible effect on qualification.

4.2.2.1.2 Similarity shall be substantiated by manufacturer attestations, specifications and product inspection reports and approved by NASA.

4.2.2.2 Analysis

4.2.2.2.1 Analysis shall not be the sole basis of qualification.

4.2.2.2.2 All analyses used for qualification shall be documented as to methods used and results obtained.

4.2.2.3 Demonstration

4.2.2.3.1 Hardware and software configurations used in demonstrations for the purpose of qualification shall be identical to flight hardware and the procedures followed must be prepared prior to the demonstration and controlled throughout the activity.

4.2.2.3.2 Qualification demonstrations shall be witnessed by the NASA, or its appointed designee, and documented in the manner designated for qualification tests.

4.2.2.4 Test

4.2.2.4.1 GSE, STE, and special test computer programs will be qualified by functional performance test.

4.2.2.4.2 Integral experiments will not, in general, be qualified in the accepted aerospace sense for flight hardware.

4.2.2.4.3 Hardware will be qualified to nominal operating pressures and g-levels to be experienced by compartments in which they are located.

4.2.2.4.4 Off-design-point qualification tests will be conducted on only those systems whose operation is required to sustain the crew.

4.2.2.4.5 Imposed environment testing shall be conducted at the subsystem level or lower. Testing shall be performed at the highest level possible within this constraint.

4.2.2.4.6 The 10-year life requirement shall be verified by test and analysis.

4.2.2.4.7 Qualification tests shall be conducted on hardware which is identical to flight hardware and has been accepted by the same tests and procedures as flight articles.

4.2.2.4.8 Tests shall be conducted to verify:

a. The performance of the hardware to perform its intended mission in the anticipated environment.
b. The impact of environmental sequencing and limit severity.
c. Electromagnetic compatibility.

4.2.2.4.9 Qualification testing shall be conducted with controlled hardware configuration and test procedures.

4.2.2.4.10 As a goal, environmental missions profile qualification testing shall be minimized.

4.2.2.4.11 Hardware that has been used on previous programs shall only be qualified for those additional critical environments.

4.2.2.4.12 A flight vehicle shall not be qualification tested for a 10-year life but shall be qualified for 10 years of operation by a combination of long-life testing and analysis.

4.2.2.4.13 Development test data may be used in lieu of qualification for all hardware levels when the data source is the only one available. Development tests in these cases will be conducted in accordance with the provisions specified for qualification testing.

4.2.3 <u>Acceptance</u>

Acceptance verifies that flight hardware has been manufactured to the qualified design, meets the design intent and will probably perform during the mission as designed. All acceptance verification shall be conducted against released engineering. Project level acceptance shall be performed by each system contractor at the factory.

4.2.3.1 <u>Analysis</u>

4.2.3.1.1 Factory acceptance of end items shall restrict the use of analysis to those features which cannot be verified by other methods or to the verification of production processes.

4.2.3.1.2 Lower level test data shall be analyzed using standard mathematical methodology to assess structural integrity.

4.2.3.1.3 Analyses shall be conducted prior to system acceptance and shall be documented in Part II (CEI) specifications.

4.2.3.2 <u>Inspection</u>

4.2.3.2.1 Receiving inspections shall be performed on flight hardware to verify that shipping or transportation damage has not occurred.

4.2.3.2.2 In-process inspections shall verify that prescribed methods and materials are used in the manufacturing processes.

4.2.3.3 <u>Demonstration</u>

None identified.

4.2.3.4 <u>Test</u>

4.2.3.4.1 Imposed environment acceptance testing should be accomplished as early as possible in the vehicle assembly to preclude costly retesting. This testing shall be severe enough to uncover deficiencies but not be severe in life cycle as to impair hardware quality.

4.2.3.4.2 The onboard checkout and fault isolation systems shall be used for vehicle acceptance and prelaunch testing at the contractor's plant.

4.2.4 Integrated Systems

Integrated systems verification is conducted to ensure the compatibility of system level interfaces and interelement performance.

4.2.4.1 Analysis

4.2.4.1.1 Analyses conducted to verify interface compatibility shall be documented for CDR.

4.2.4.1.2 Analysis shall not be the sole verification of interelement performance.

4.2.4.2 Demonstration

4.2.4.2.1 Within the limits imposed by terrestrial environments, the performance of each module shall be demonstrated while interfaced with a fully functional replica of the orbiting station prior to transport to the launch site.

4.2.4.2.2 Demonstrations shall be conducted by the contractor using accepted modules.

4.2.5 Prelaunch Checkout

Prelaunch verification ascertains the readiness of the flight hardware for launch and ground support equipment to support that launch.

4.2.5.1 Inspection

4.2.5.1.1 A complete visual inspection of each module/GSE shall be performed at the launch site to ensure satisfactory physical condition.

4.2.5.2 Demonstration

4.2.5.2.1 Prelaunch operations shall be performed in accordance with pre-established procedures.

4.2.5.2.2 Successful completion of prelaunch operations shall constitute verification by demonstration.

4.2.5.3 Test

4.2.5.3.1 Prelaunch testing of modules shall be restricted to those tests necessary to ascertain integrity following transport and to the checkout of module/orbiter interfaces.

4.2.5.3.2 Offloaded hardware shall not be functionally tested at the launch site unless degradation is apparent from transport data.

4.2.6 Flight/Mission Operations

Verification during flight/mission operations is conducted to ensure mission readiness and continuity while in orbit by means of inherent onboard systems.

4.2.6.1 Analysis

4.2.6.1.1 Continuous evaluation of module and/or station status shall be made by the analysis of on-orbit data.

4.2.6.1.2 Analyses shall use only validated data and should utilize common mathematical methodologies

4.2.6.2 Demonstration

4.2.6.2.1 Successful completion of mission operations governed by established procedures shall constitute verification by demonstration.

4.2.6.3 Test

4.2.7 Post-Flight

This paragraph is not applicable to this specification.

4.3 Verification Matrix

This section contains a one-for-one cross reference of each verification requirement for each Section 3 requirement and identifies the method by which each requirement is to be verified.

4.4 Test Support Requirements

4.4.1 Facilities and Equipment

4.4.1.1 Test equipment needed to simulate inputs/outputs to subsystems shall be compatible with the onboard checkout and fault isolation system and other interfacing subsystems

4.4.1.2 All test equipment shall be certified to ensure that no damage or degradation is introduced into the test hardware or that results will not include test equipment error.

4.4.1.3 Special high levels of atmospheric or surface cleanliness shall not be required for verification processes unless necessary to the requirement being verified.

4.4.1.4 Tests shall be conducted and test equipment/articles located for most beneficial use to the entire mission duration.

4.4.1.5 Tests involving incremental or complete performance at more than one location shall be designed to use common test equipment and procedures.

4.4.2 Articles

4.4.2.1 A test article constructed of qualification test hardware shall be designed and operated to:

4.4.2.1.1 Verify integrated operation of ISS as a unit prior to the mission.

4.4.2.1.2 Verify integrated operation of GSS modules with ISS prior to mission.

4.4.2.1.3 Demonstrate compatibility of modules prior to first mate on orbit.

4.4.2.1.4 Perform continuing mission support activities such as configuration control, orbital troubleshooting, flight crew training, principal investigator orientation, maintenance plan and procedure development, etc.

4.4.2.2 A test article constructed of development hardware shall be designed and operated to develop a system with integrated electrical/electronic subsystems and computer programs.

4.4.2.3 Test article hardware and configuration shall meet fidelity requirement established for the highest test type for which it is used.

4.4.3 Software

4.4.3.1 The requirements established for test support software in the Program Specification, PS02925, paragraphs 4.4.3.1 and 4.4.3.2, shall apply to Modular Space Station elements.

5. PREPARATION FOR DELIVERY

5.1 Protection from Natural Environment Extremes

The modules and components of the Modular Space Station Program shall be protected from natural environmental extremes which are in excess of the design requirements specified in Section 3.2.7 of each applicable specification. Environmental extremes specified in NASA documents, NASA TMX-53865, and NASA TMX-53872 shall be used as a basis for providing protection.

5.2 Preservation, Packaging and Packing

Sound packaging engineering principles shall be used in the design of shipping containers and the development of packaging techniques and handling instructions. Selection of packaging and preservation methods shall be in general accordance with FED-STD-102 as well as being compatible with environmental limitations, transportation and handling environments, and storage requirements specified herein.

5.2.1 Packing

Basic packing shall protect the item during shipment and storage, provide a method for handling during loading, off loading, and storage activity, and provide proper identification.

5.2.2 Repair Parts/Logistic Option Items

Repair parts and logistic option items listed on the loose equipment shall be shipped separately from modules. The following criteria shall be used in preparing loose items for shipment:

a. Facilitate economical shipment
b. Prevent damage to sensitive equipment
c. Prevent hazardous conditions (ordnance items)
d. Permit installation of encironmental control devices and during shipment.

The loose item equipment list for each prime equipment CEI shall be approved by the procuring agency prior to implementation.

5.2.3 Package Construction

Packages shall be constructed with provisions to permit unpacking for periodic inspection and repacking of the inspected items in the original container. Packages shall also be constructed to immobilize and cushion the items against damage during shipping and handling.

5.2.4 Protective Devices

Provisions shall be made to install protective devices on each module, as required, to prevent damage during shipment. During shipment flight hardware may be replaced by environmental control equipment to assure safe delivery.

5.2.5 Transportation Instrumentation

Instrumentation shall be installed on each module to measure and record the environment to which module has been subjected while being transported. This transportation instrumentation shall record measurements such as propellant tank humidity, temperature, pressure, stress, vibration and ambient conditions. A transportation instrumentation program shall be prepared and submitted to the procuring activity for approval prior to implementation.

5.3 Marking

Marking for shipment and storage shall be as specified in MIL-STD-129E.

6. NOTES

None identified

10. APPENDIX

Appendix A— Intraproject Interface Requirements
ISS Modules/Logistics Modules

Project Modular Space Station	VERIFICATION CROSS REFERENCE INDEX	Spec No. RS02927 Dated 10 December 1971 Page 67

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:

1. Test
2. Similarity
3. Analysis
4. Inspection
5. Demonstration

N/A - Not Applicable

VERIFICATION PHASE:

A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

Section 3.0 Performance/ Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.0	X								
3.1	X								
3.1.1	X								
3.1.1.1	X								
3.1.1.2					3				4.2.4.1
3.1.1.3					3				4.2.4.1
3.1.1.4	X								
3.1.1.5	X								
3.1.2	X								
3.1.2.1							5		4.2.6.2
3.1.2.2							3		4.2.6.1
3.1.2.3							3		4.2.6.1
3.1.3	X								
3.1.3.1	X								
3.1.3.1.1	X								
3.1.3.1.2					3				4.2.4.1
3.1.3.1.3					3				4.2.4.1
3.1.3.1.4	X								
3.1.3.1.5							5		4.2.6.2
3.1.3.1.6							5		4.2.6.2
3.1.3.1.7							5		4.2.6.2
3.1.3.1.8							5		4.2.6.2

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REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:

1. Test
2. Similarity
3. Analysis
4. Inspection
5. Demonstration

N/A - Not Applicable

VERIFICATION PHASE:

A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

Section 3.0 Performance/ Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.1.3.1.9							5		4.2.6.2
3.1.3.1.10	X								
3.1.3.1.11							5		4.2.6.2
3.1.3.1.12							5		4.2.6.2
3.1.3.1.13							5		4.2.6.2
3.1.3.1.14							5		4.2.6.2
3.1.3.2	X								
3.1.3.2.1							5		4.2.6.2
3.1.3.2.2							5		4.2.6.2
3.1.3.2.3						4			4.2.5.1
3.1.3.2.4						4			4.2.5.1
3.1.3.2.5							5		4.2.6.2
3.1.3.2.6						5			4.2.5.2
3.1.3.2.7						5			4.2.5.2
3.1.3.2.8						4			4.2.5.1
3.1.3.2.9						4			4.2.5.1
3.1.3.2.10						5			4.2.5.2
3.1.3.2.11						5			4.2.5.2
3.1.3.2.12	X								
3.1.3.2.13									
3.1.3.2.14						4			4.2.5.1
3.1.3.2.15						4			4.2.5.1
3.1.3.2.16							5		4.2.6.2

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REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:

1. Test
2. Similarity
3. Analysis
4. Inspection
5. Demonstration

N/A - Not Applicable

VERIFICATION PHASE:

A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

Section 3.0 Performance/ Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.1.3.2.17							5		4.2.6.2
3.1.3.2.18						4			4.2.5.1
3.1.3.3	X								
3.1.3.3.1							3		4.2.6.1
3.1.3.3.2							5		4.2.6.2
3.1.3.3.3							5		4.2.6.2
3.1.3.3.4							5		4.2.6.2
3.1.3.3.5							5		4.2.6.2
3.1.3.3.6							5		4.2.6.2
3.1.3.3.7							3		4.2.6.1
3.1.3.3.8							5		4.2.6.2
3.1.3.3.9							5		4.2.6.2
3.1.3.3.10							5		4.2.6.2
3.1.3.3.11					5				4.2.4.2
3.1.3.3.12							5		4.2.6.2
3.1.3.3.13							3		4.2.6.1
3.1.3.3.14					5				4.2.4.2
3.1.3.3.15							5		4.2.6.2
3.1.3.3.16							5		4.2.6.2
3.1.4	X								
3.1.5	X								
3.1.6	X								

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REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:

1. Test
2. Similarity
3. Analysis
4. Inspection
5. Demonstration

N/A - Not Applicable

VERIFICATION PHASE:

A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

Section 3.0 Performance/ Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.1.7	X								
3.2	X								
3.2.1	X								
3.2.1.1	X								
3.2.1.1.1					5				4.2.4.2
3.2.1.1.2					3				4.2.4.1
3.2.1.1.3					3				4.2.4.1
3.2.1.1.3.1					3				4.2.4.1
3.2.1.1.3.2					3				4.2.4.1
3.2.1.1.4							3		4.2.6.1
3.2.1.1.5					3				4.2.4.1
3.2.1.1.6				4					4.2.3.2
3.2.1.1.7					5				4.2.4.2
3.2.1.1.8					5				4.2.4.2
3.2.1.1.9					3				4.2.4.1
3.2.1.1.10							5		4.2.6.2
3.2.1.1.11					5				4.2.4.2
3.2.1.1.12							3		4.2.6.1
3.2.1.1.13					5				4.2.4.2
3.2.1.1.14					5				4.2.4.2
3.2.1.1.15					5				4.2.4.2
3.2.1.1.16					3				4.2.4.1
3.2.1.1.17							5		4.2.6.2

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REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:

1. Test
2. Similarity
3. Analysis
4. Inspection
5. Demonstration

N/A - Not Applicable

VERIFICATION PHASE:

A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

Section 3.0 Performance/ Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.1.1.18							3		4.2.6.1
3.2.1.1.19				3					4.2.3.1.2
3.2.1.1.20				3					4.2.3.1.2
3.2.1.1.21					5				4.2.4.2
3.2.1.1.22				3					4.2.3.1.2
3.2.1.1.23					5				4.2.4.2
3.2.1.1.24					5				4.2.4.2
3.2.1.2	X								
3.2.1.2.1							5		4.2.6.2
3.2.1.2.2							5		4.2.6.2
3.2.1.2.3					5				4.2.4.2
3.2.1.3	X								
3.2.1.3.1					5				4.2.4.2
3.2.2	X								
3.2.2.1						4			4.2.5.1
3.2.2.2						4			4.2.5.1
3.2.2.3				4					4.2.3.2
3.2.2.4							3		4.2.6.1
3.2.2.5							3		4.2.6.1
3.2.3	X								
3.2.3.1							5		4.2.6.2
3.2.3.2							3		4.2.6.1

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REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:

1. Test
2. Similarity
3. Analysis
4. Inspection
5. Demonstration

N/A - Not Applicable

VERIFICATION PHASE:

A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

Section 3.0 Performance/ Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.3.3	X								
3.2.3.4							3		4.2.6.1
3.2.3.5							3		4.2.6.1
3.2.3.6				3					4.2.3.1.3
3.2.3.7				3					4.2.3.1.3
3.2.3.8				3					4.2.3.1.3
3.2.3.9							5		4.2.6.2
3.2.3.10				3					4.2.3.1.3
3.2.3.11				3					4.2.3.1.3
3.2.4	X								
3.2.4.1	X								
3.2.4.2					5				4.2.4.2
3.2.4.3	X								
3.2.4.4					5				4.2.4.2
3.2.4.5					5				4.2.4.2
3.2.4.6									
3.2.4.7					5				4.2.4.2
3.2.4.8							3		4.2.6.1
3.2.4.9					5				4.2.4.2
3.2.4.10							5		4.2.6.2
3.2.4.11				3					4.2.3.1.2
3.2.4.12				3					4.2.3.1.2
3.2.4.13							3		4.2.6.1

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REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Test
2. Similarity
3. Analysis
4. Inspection
5. Demonstration

N/A - Not Applicable

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

Section 3.0 Performance/ Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.4.14							3		4.2.6.1
3.2.5	X								
3.2.5.1							5		4.2.6.2
3.2.5.2							3		4.2.6.1
3.2.5.3					3				4.2.4.1
3.2.5.4							5		4.2.6.2
3.2.6	X								
3.2.6.1	X								
3.2.6.1.1				3					4.2.3.1.3
3.2.6.1.2				3					4.2.3.1.3
3.2.6.2	X								
3.2.6.2.1							3		4.2.6.1
3.2.6.2.2					5				4.2.4.2
3.2.6.2.3					5				4.2.4.2
3.2.6.2.4				3					4.2.3.1.3
3.2.6.2.5					5				4.2.4.2
3.2.6.2.6					5				4.2.4.2
3.2.6.2.7				3					4.2.3.1.3
3.2.6.2.8					5				4.2.4.2
3.2.6.2.9					3				4.2.4.1
3.2.6.2.10							5		4.2.6.2
3.2.6.2.11				3					4.2.3.1.3

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REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:

1. Test
2. Similarity
3. Analysis
4. Inspection
5. Demonstration

N/A - Not Applicable

VERIFICATION PHASE:

A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

Section 3.0 Performance/ Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.6.2.12				4					4.2.3.2
3.2.6.2.13					3				4.2.4.1
3.2.6.3	X								
3.2.6.3.1							5		4.2.6.2
3.2.6.4	X								
3.2.6.4.1							5		4.2.6.2
3.2.6.4.2				3					4.2.3.1.3
3.2.6.4.3					3				4.2.4.1
3.2.6.5	X								
3.2.6.5.1							5		4.2.6.2
3.2.6.5.2					3				4.2.4.1
3.2.6.5.3					3				4.2.4.1
3.2.6.5.4					3				4.2.4.1
3.2.6.5.5							5		4.2.6.2
3.2.6.6	X								
3.2.6.6.1					3				4.2.4.1
3.2.6.6.2							3		4.2.6.1
3.2.7	X								
3.2.7.1	X								
3.2.7.1.1				4					4.2.3.2
3.2.7.1.2				4					4.2.3.2
3.2.7.2	X								

Project Modular Space Station	VERIFICATION CROSS REFERENCE INDEX	Spec No. RS02927 Dated 10 December 1971 Page 75

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:

1. Test
2. Similarity
3. Analysis
4. Inspection
5. Demonstration

N/A - Not Applicable

VERIFICATION PHASE:

A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

Section 3.0 Performance/ Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.7.2.1				3					4.2.3.1.3
3.3	X								
3.3.1	X								
3.3.2	X								
3.3.2.1				4					4.2.3.2
3.3.2.2	X								
3.3.2.2.1				4					4.2.3.2
3.3.2.2.2				4					4.2.3.2
3.3.2.2.3				4					4.2.3.2
3.3.2.2.4				4					4.2.3.2
3.3.2.2.5				4					4.2.3.2
3.3.2.2.6				3					4.2.3.1.3
3.3.2.2.7				4					4.2.3.2
3.3.3	X								
3.3.4				4					4.2.3.2
3.3.5				4					4.2.3.2
3.3.6				3					4.2.3.1.3
3.3.6.1	X								
3.3.6.1.1				3					4.2.3.1.3
3.3.6.1.2				3					4.2.3.1.3
3.3.6.1.3				3					4.2.3.1.3

Project Modular Space Station	VERIFICATION CROSS REFERENCE INDEX	Spec No. RS02927 Dated 10 December 1971 Page 76

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:

1. Test
2. Similarity
3. Analysis
4. Inspection
5. Demonstration

N/A - Not Applicable

VERIFICATION PHASE:

A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

Section 3.0 Performance/ Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.3.6.1.4				3					4.2.3.1.3
3.3.7				4					4.2.3.2
3.3.8				4					4.2.3.2
3.3.9				4					4.2.3.2
3.3.10	X								
3.3.10.1							3		4.2.6.1
3.3.10.2							3		4.2.6.1
3.3.11	X								
3.3.11.1							5		4.2.6.2
3.3.12				4					4.2.3.2
3.3.13				4					4.2.3.2
3.3.14				4					4.2.3.2
3.3.15				4					4.2.3.2
3.4	X								
3.4.1							5		4.2.6.2
3.4.2							5		4.2.6.2
3.4.3							5		4.2.6.2
3.4.4							3		4.2.6.1
3.5	X								

Project Modular Space Station	VERIFICATION CROSS REFERENCE INDEX	Spec No. RS02927 Dated 10 December 1971 Page 77

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Test
2. Similarity
3. Analysis
4. Inspection
5. Demonstration

N/A - Not Applicable

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

Section 3.0 Performance/ Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.5.1	X								
3.5.2	X								
3.5.3	X								
3.5.4	X								
3.5.5	X								

MODULAR SPACE STATION PROJECT
APPENDIX A
INTRAPROJECT INTERFACE REQUIREMENTS
ISS MODULE/LOGISTICS MODULE

3.0 REQUIREMENTS

This appendix contains requirements affecting the interfaces within the Modular Space Station Project. These requirements are specified by the project manager and as such do not necessitate bilateral agreement.

3.1 CEI Definition

3.1.1 The ISS Module CEI is defined in CP 02929, dated (TBD) and the Logistics Module CEI is defined in CP 02930, dated (TBD).

3.1.2 The physical and functional interface between the ISS and the Log M's shall be identical at the end docking port and at one of the radial docking ports of the Crew/Operations Module. These locations shall normally be reserved for Log M docking. All requirements specified in this section shall be provided at these ports.

3.1.3 The ISS shall be capable of docking with a Log M at any docking port and the interface shall provide for crew access to the habitable compartment of the Log M.

3.2 Characteristics

3.2.1 Performance

3.2.1.1.1 The ISS shall provide 540 cc/sec (136 cfm) conditioned air to each docked Log M. The Log M's shall provide distribution and circulation.

3.2.1.1.2 The ISS shall provide each docked Log M with makeup O_2 and N_2, contingency O_2 and N_2, compartment pressurization and depressurization and equipment pressurization. These provisions shall include requirements for operations and control of the EVA airlock in the Log M.

3.2.1.1.3 The ISS shall interface with the Logistics Module for transfer and control of high pressure O_2 and N_2 for use as makeup atmosphere.

3.2.1.2 Structural/Mechanical

The ISS module docking and latch mechanisms shall interface with the Logistics Modules, providing the capability for direct docking of the Log M's by the Shuttle Orbiter and for completion of an airlock at the interface.

3.2.1.3 Electrical Power

The electrical power for the docked Logistics Module shall be supplied through an interface which is common to all docking ports. A 24-hour average power allocation of 250 watts of load at 115 vdc (±3 vdc) shall be provided for each Log M by the ISS modules.

3.2.1.4 Propulsion

The ISS modules shall provide for propellant (N_2H_4) and pressurant (N_2) umbilicals at each docking port designated for Logistics Modules.

3.2.1.5 Communications

The ISS modules shall provide the capability for installation of audio terminal units in the Log M through the utilization of the data bus interface. Caution signals shall also be carried on the data bus. Additional conductors shall be provided at the interface for warning functions.

3.2.1.6 Data Management

ISS modules shall interface with logistic modules through an extension of the ISS data bus into the logistic modules at each docking port.

3.2.1.7 Crew Habitability and Protection

3.2.1.7.1 The habitable compartments of the ISS and Log M shall have compatible crew accommodations, including crew aids such as restraints and locomotion devices and cargo handling equipment, which shall provide for safe and convenient crew operations utilizing the habitable compartments of each CEI and the docking port interface volume.

3.2.1.8 Onboard Checkout and Fault Isolation

The ISS shall interface electrically with the Logistics Module via the data management function for purposes of monitoring parameters related to crew or equipment safety.

3.2.2 Physical

3.2.2.1 Logistics Module and ISS shall use a standard docking mechanism. NCC

3.2.3 Reliability

This paragraph is not applicable to this appendix.

3.2.4 Maintainability

This paragraph is not applicable to this appendix.

3.2.5 Operational Availability

None identified

3.2.6 Safety

This paragraph is not applicable to this appendix.

3.2.7 Environment

This paragraph is not applicable to this appendix.

3.2.8 Transportability/Transportation

This paragraph is not applicable to this appendix.

3.3 Design and Construction Standards

This paragraph is not applicable to this appendix.

3.4 Logistics

This paragraph is not applicable to this appendix.

3.5 Personnel and Training

This paragraph is not applicable to this appendix.

3.6 Exchange Hardware and Delivery Dates

None identified

3.7 Exchange Services and Performance Periods

None identified