NOVEMBER 1971

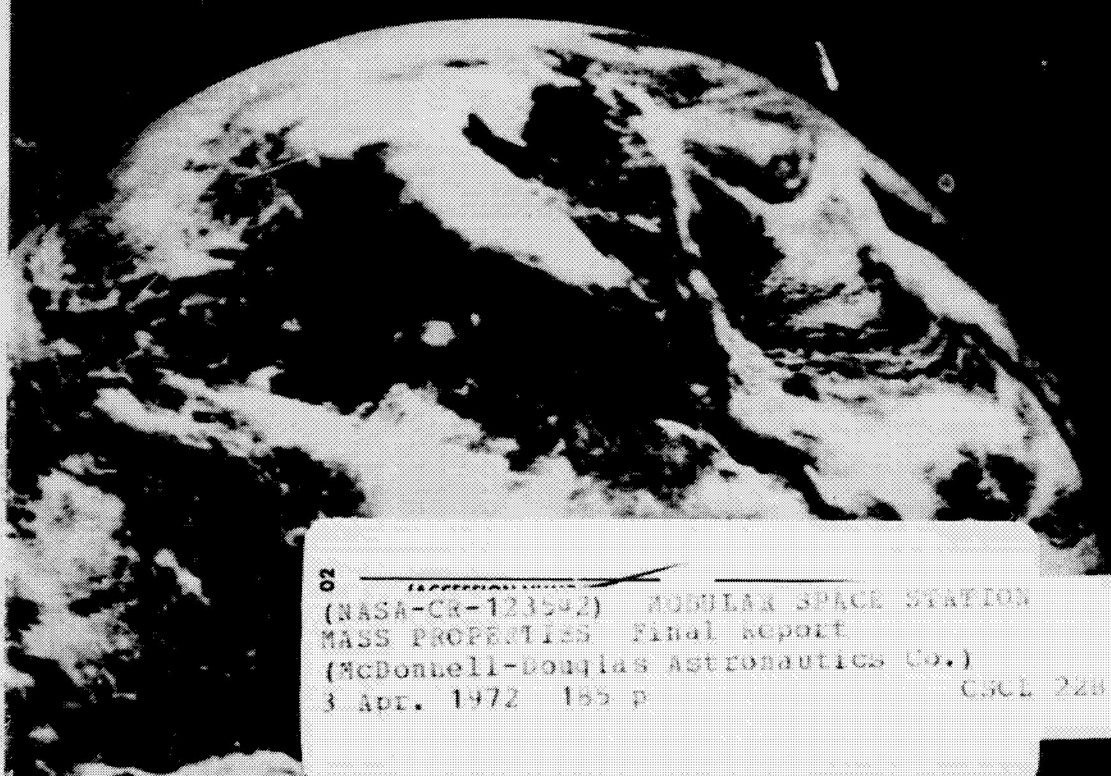
MDC G2599

SPACE STATION

MSFC-DPD-235/DR NO. SE-07

MODULAR SPACE STATION MASS PROPERTIES-FINAL REPORT

CONTRACT NAS8-25140



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APPROVED BY:

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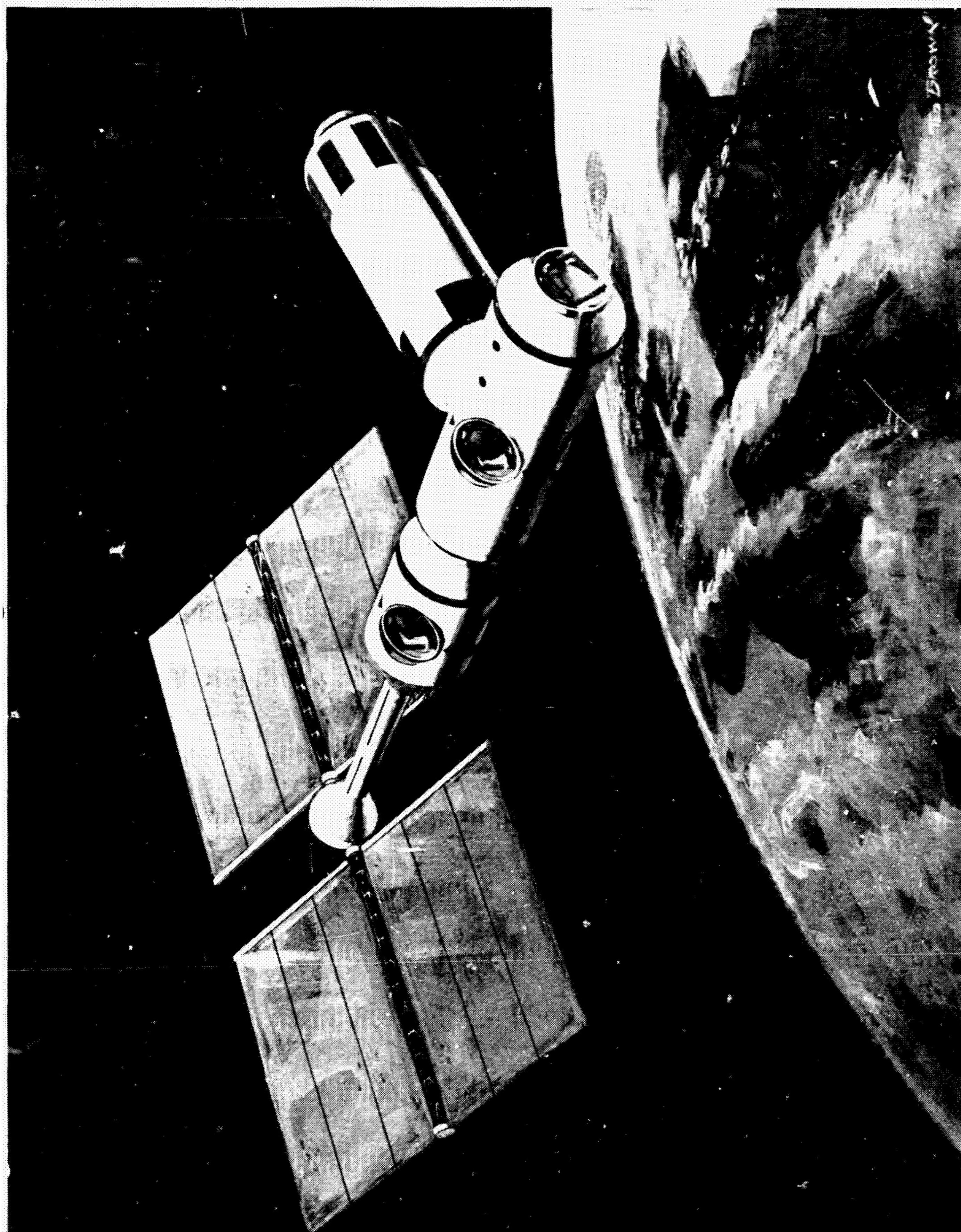

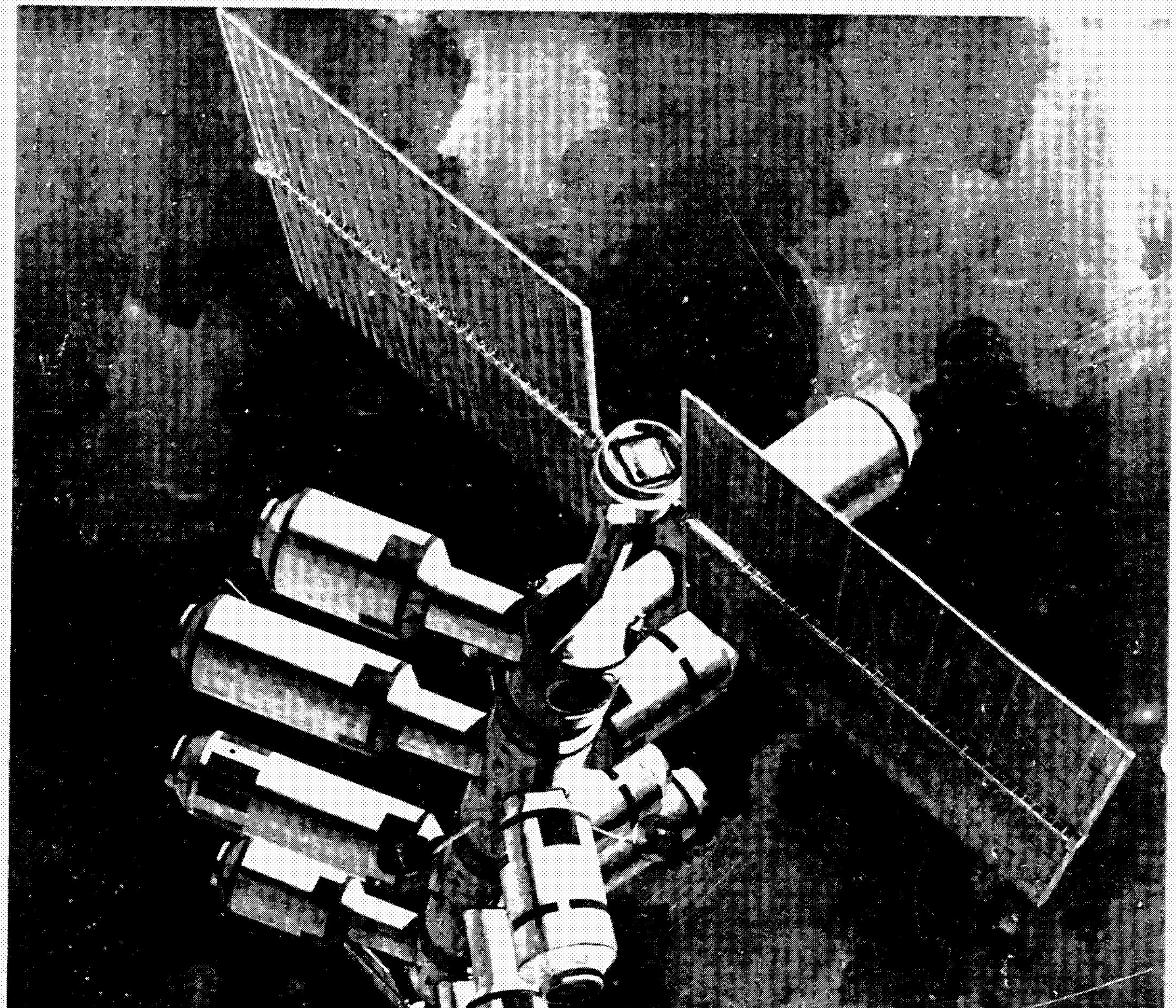

PREFACE

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 design were accomplished to the depth necessary for departure from Phase B.

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) consists 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 SE-07.

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

Category	Designation	DR Number	Title
Configuration	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

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SUBJECT REFERENCE MA

LEGEND:

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

	CM				MA		MF	
	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)
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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SUBJECT REFERENCE MATRIX

MA		MF	MP			SE								
[illegible] 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
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Section 1
INTRODUCTION

1.1 BACKGROUND

With the advent of the Space Shuttle in the late 1970's, 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-ft-diameter Space Station, launched by the Saturn INT-21 and supporting a complement of 12, has been completed to a Phase B level and documented in the DRL-160 series. Recently completed studies are centered around a Space Station comprised of smaller, Shuttle-launched modules. These modules could ultimately be configured to provide for a crew of the same size as on the 33-ft-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 Phase A—level study results are document 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) (shown in the frontispiece), which will house a crew of 12 and provide a capability equivalent to the 33-ft INT-21-launched Space Station. GSS logistics support will use a Crew Cargo Module capable of transporting a crew of six.

During ISS operations, five Research Applications Modules (RAM's) will be assembled to the Space Station. Three of these will be returned prior to completion of the GSS. In the GSS configuration, 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.

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

This is the final report on mass properties which is an update beyond that presented in other documents. It includes the final status update of the ISS modules and Logistic Module plus incorporation of the GSS Module additions. The purpose of this document is to present the Space Station mass properties and to serve as a basic document for subsequent mass property reports.

Weights for the Initial Space Station Modules and the Logistic Module are summarized in Section 1, which is intended for management review.

Section 2 contains the orbiting vehicle weight summary and sequences mass properties.

Section 3 contains the detailed status reporting of the Initial Space Station baseline design configuration.

Section 4 contains the additional provisions required for the GSS.

Section 5 contains the status reporting on the Logistic Module.

Section 6 contains the Logistic Module options for the initial manning.

Section 7 contains the detail substantiation mass properties for the Space Station core modules and definition of terms.

The format of this report facilitates the review of the Mass Properties Control and Integration Program, in accordance with MIL-M-38310A (USAF) as specified in the Work Statement and the Mass Properties Data Requirements on the Contract Data Requirements List (DRL-17). The functional codes used throughout this report are those of MIL-M-38310A, as used on the Manned Orbital Laboratory (MOL) for the USAF. The changes from the basic code have been made in the electronic functional codes to more clearly align the codes with the subsystems. A wiring functional code was also added to facilitate historical data retrieval.

1.2.1 Space Station Spacecraft Weight Summary

The weights reported for the Initial Space Station and Logistic Module in Table 1-1 are summarized to permit definition of the booster margin/ discretionary payload. The ISS in this report is defined as the baseline

Table 1-1
GROSS DISCRETIONARY PAYLOAD

Description	Mass (kg)		Mass (1 bm)	
1 Minimum Launch Mass	22,056		48,629	
Power/Subsystems Module		7,943		17,513
Crew/Operations Module		7,043		15,529
GPL Module		7,070		15,587
2 Logistic Options for Logistics Module-1	4,995		11,012	
Power/Subsystems Module		1,972		4,347
Crew/Operations Module		1,698		3,743
GPL Module		1,325		2,922
3 Logistic System	3,011		6,638	
Logistics Module		3,011		6,638
Total Manning Mass	30,067		66,279	
Discretionary Margin	6,226		13,721	
Total Target Capability	36,288		80,000	

1 See Section 3 for additional details

2 See Section 5 for additional details.

3 See Section 6 for additional details.

design configuration with the detail weights summarized in Section 3 for the ISS Modules and Section 5 for the Logistic Module. The baseline design configurations are all under their design to weight of 20,000 lb (9,072 Kg).

Table 1-2 summarizes the subsystem mass for the ISS Power/Subsystems, Crew/Operations, GPL, and Logistic Modules, plus the logistic options necessary for initial manning.

Table 1-3 summarizes the gross mass changes since the last report. Added details are available in Sections 3 and 5.

Table 1-2

INITIAL SPACE STATION AND LOGISTIC MODULE SUBSYSTEM MASS SUMMARY

Code	Description	Power/Subsystems Module No. 1 Mass (lbm)	Power/Subsystems Module No. 1 Mass (kg)	Crew/ Operations Module No. 1 Mass (lbm)	Crew/ Operations Module No. 1 Mass (kg)	GPL Module Mass (lbm)	GPL Module Mass (kg)	Logistic Module Mass (lbm)	Logistic Module Mass (kg)
02.00	Structure	3,308	1,501	3,480	1,579	3,783	1,716	2,647	1,200
03.00	Meteoroid/Thermal Protection	2,108	956	2,036	924	2,002	908	1,104	501
04.00	Docking Provisions	1,539	698	1,539	698	615	279	616	279
06.00	Propulsion	736	334	316	143	54	24	158	72
07.00	Prime Power	4,625	2,098	15	7	15	7	--	--
08.00	Power Conditioning and Distribution	673	305	287	130	288	131	77	35
10.00	Electronics	1,386	628	2,523	1,145	2,063	935	456	207
11.00	Wiring	580	263	794	360	1,032	468	165	75
12.00	Atmosphere and Thermal Control	831	377	1,287	583	1,259	571	740	336
14.00	Crew Lift Support and Interiors	425	[illegible]	2,568	1,164	665	302	435	197
17.00	Crew Equipment and Crew	--	--	--	--	--	--	--	--
18.00	GPL and Experiment Provisions	--	--	--	--	3,163	1,435	--	--
21.00	Residuals	549	249	684	310	648	294	240	109
22.00	Reserves	223	101	--	--	--	--	--	--
23.00	Inflight Losses	530	240	--	--	--	--	--	--
--	Minimum-Launch Total	17,513	7,943	15,529	7,043	15,587	7,070	6,638	3,011
--	① Cargo (Set of Lo[illegible]stic Options)	--	--	--	--	--	--	11,012	4,995
--	Discretionary Margin	2,487	1,129	4,471	2,029	4,413	2,002	2,350	1,066
--	Target	20,000	9,072	20,000	9,072	20,000	9,072	20,000	9,072

① See Section 6 for additional details.

1st Flight 4,995 Kg (11,012 lbm)
2nd Flight 4,293 Kg (9,466 lbm)
3rd Flight 3,963 Kg (8,738 lbm)

Table 1-3

SPACE STATION AND LOGISTIC MODULE
MASS CHANGE SUMMARY

	Mass	
Module	kg	lbm
Power/Subsystems	- 518	-1, 312
Crew/Operations	- 722	-1, 592
GPL	-1, 102	-2, 429
Logistic	+ 285	+ 628
Total	-2,057	-4, 705

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Section 2
ISS AND GSS ORBITING VEHICLE

Mass properties data presented in this section are detailed in Section 3 and 4 for the Space Station Modules and Section 5 for the Logistics Module. The mass properties interface with the Orbiter was extracted from the SOAR/ Shuttle Data Book, MDC G2327, dated May 1971.

To illustrate the total ISS and GSS highly variable mass properties characteristics throughout the mission a gross approximation is included. Section 6 details the first three logistic flight mass requirements. A buildup sequence for this is given in Figures 2-1 through 2-4. This buildup sequence was derived with certain constraints which are identified with the buildup sequence as follows.

From the third step of the buildup shown in Figure 2-1, the GPL is radially docked to the Crew/Operations Module, which is a permanent position. The remaining two radial docking ports and the end docking port on the crew module are used primarily for logistics docking. The docking ports on the Crew/Operations Module are used in lieu of those on the Power/Subsystems Module to ease the task of unloading the Logistics Modules. For the docking of the Logistics Modules, it is assumed that the incoming Logistics Module does not dock at the same docking port as that used by the outgoing Logistics Module. Therefore, with two docked Logistics Modules, a third open docking port is available for continued buildup. This mode of operation reduces the docking operations of the Shuttle.

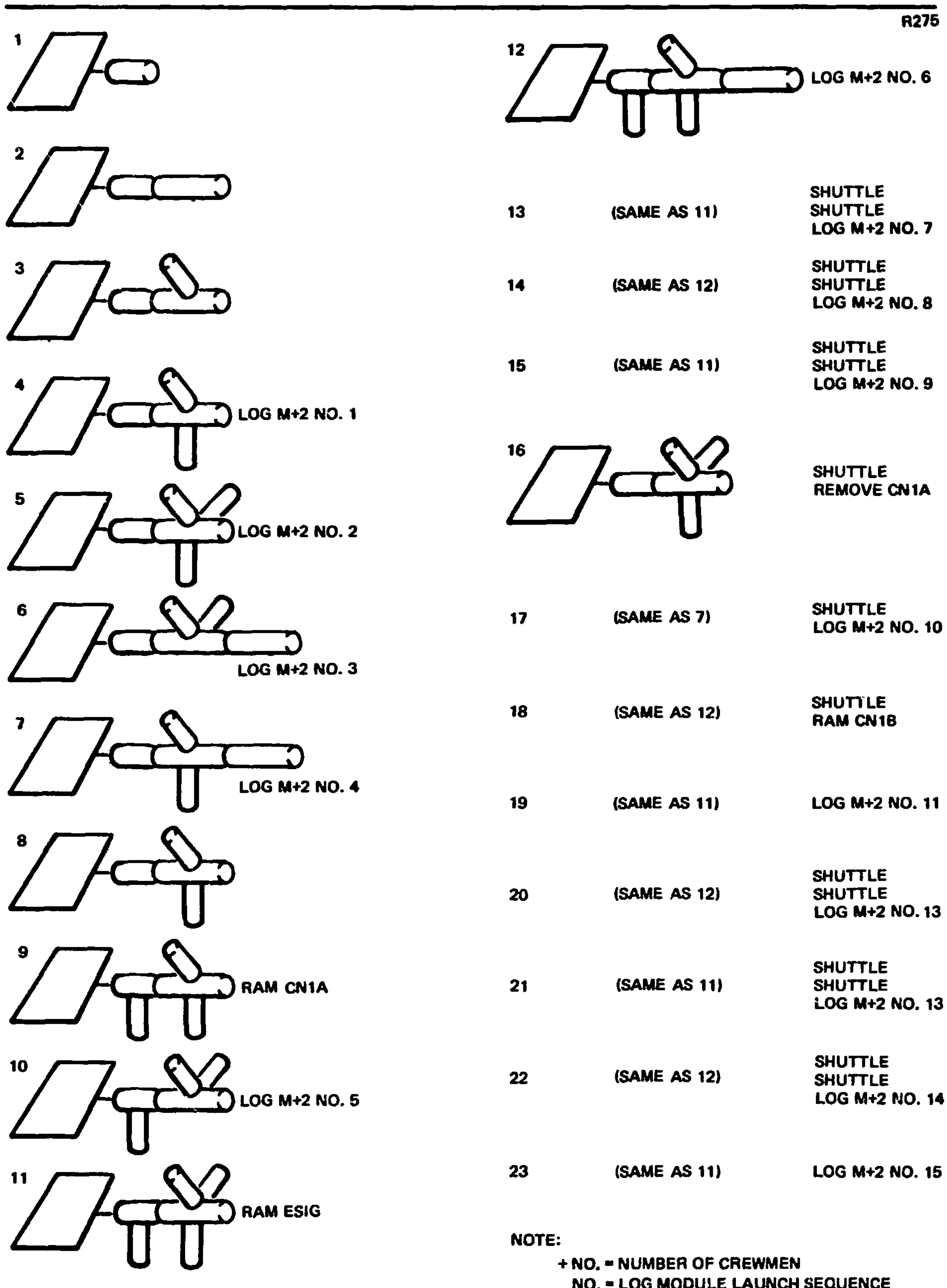


Figure 2-1. ISS Phase of Space Station Program

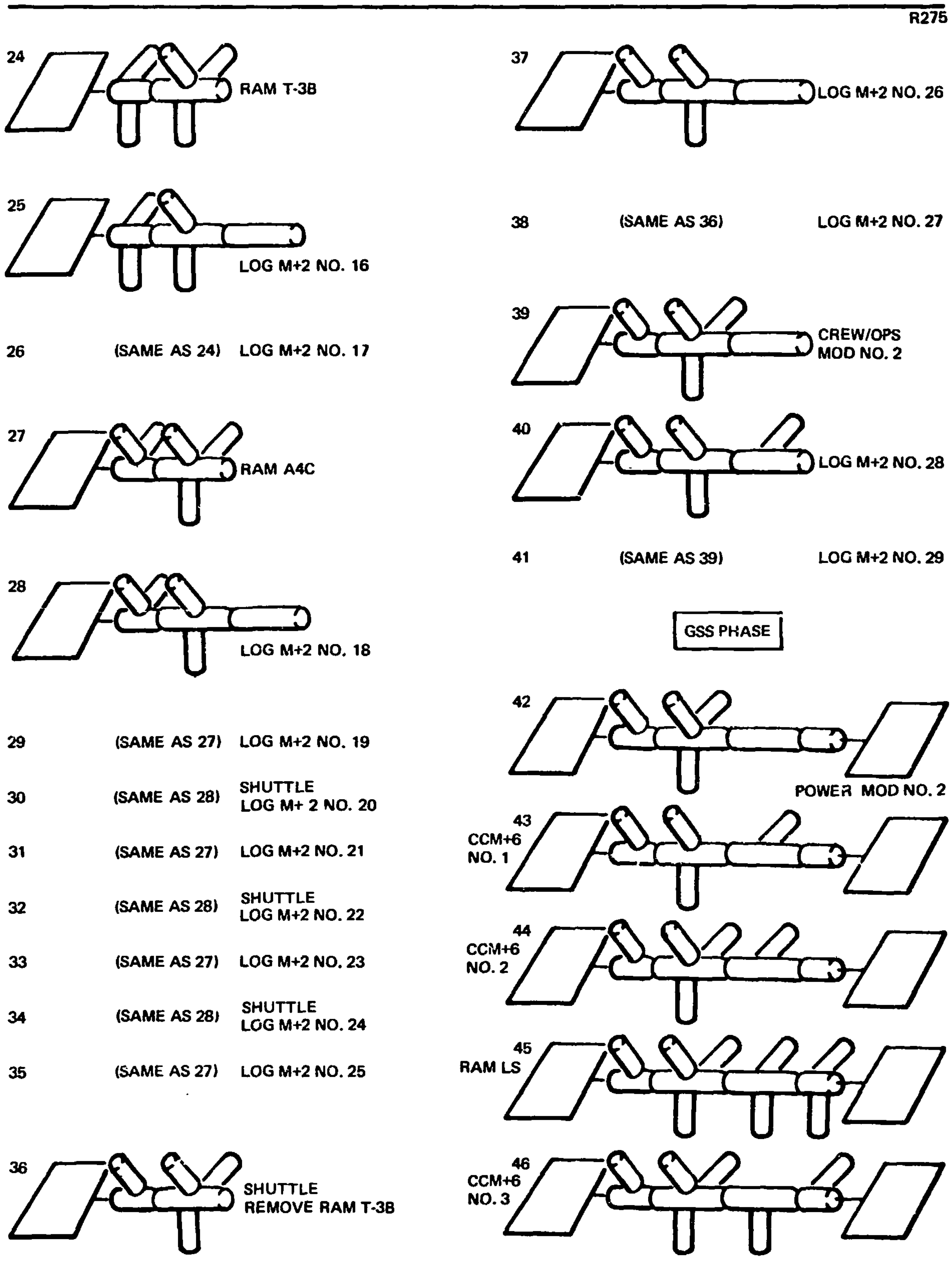


Figure 2-2. ISS and GSS Phase of Space Station Program

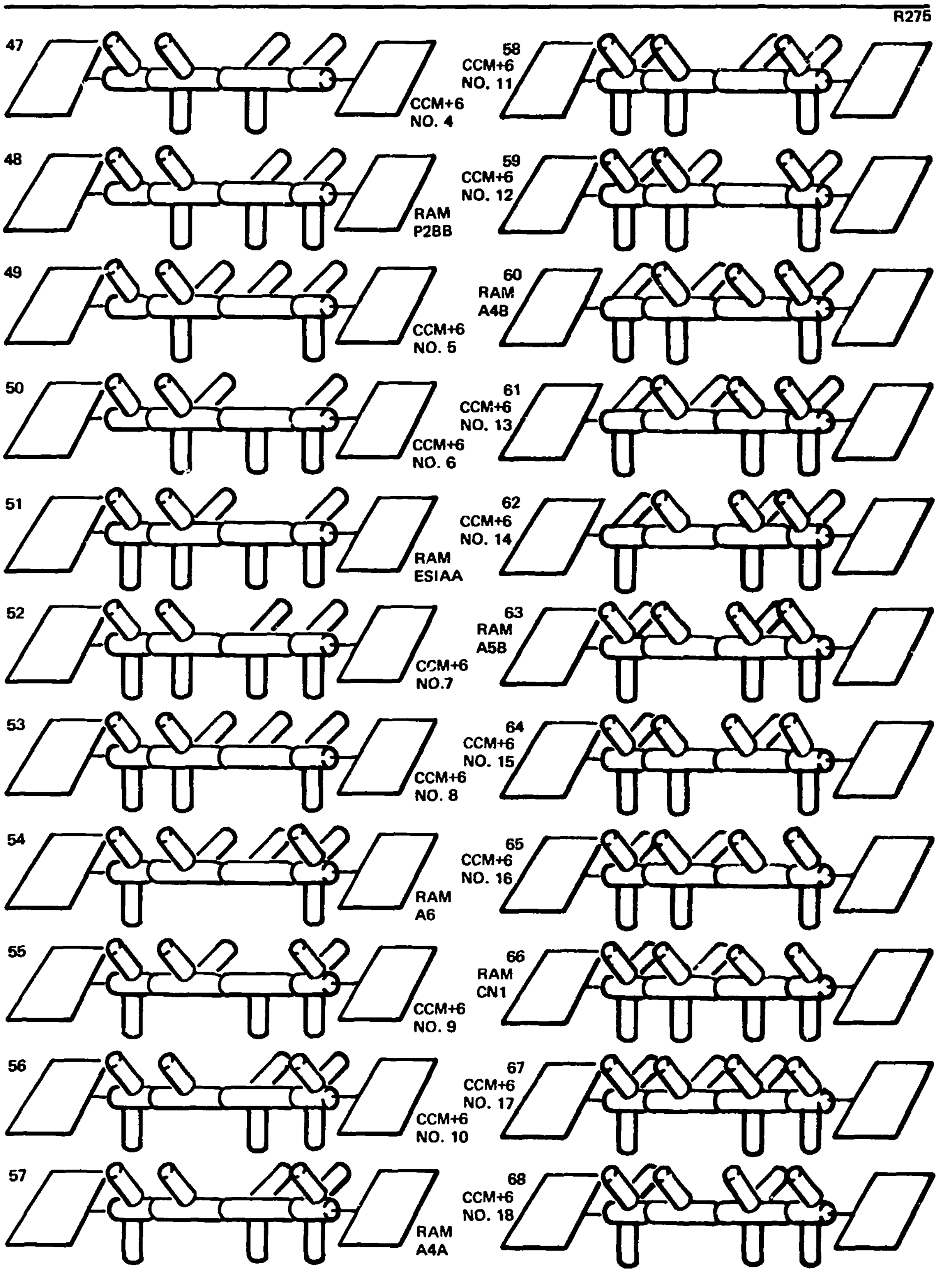


Figure 2-3. GSS Phase of Space Station Program

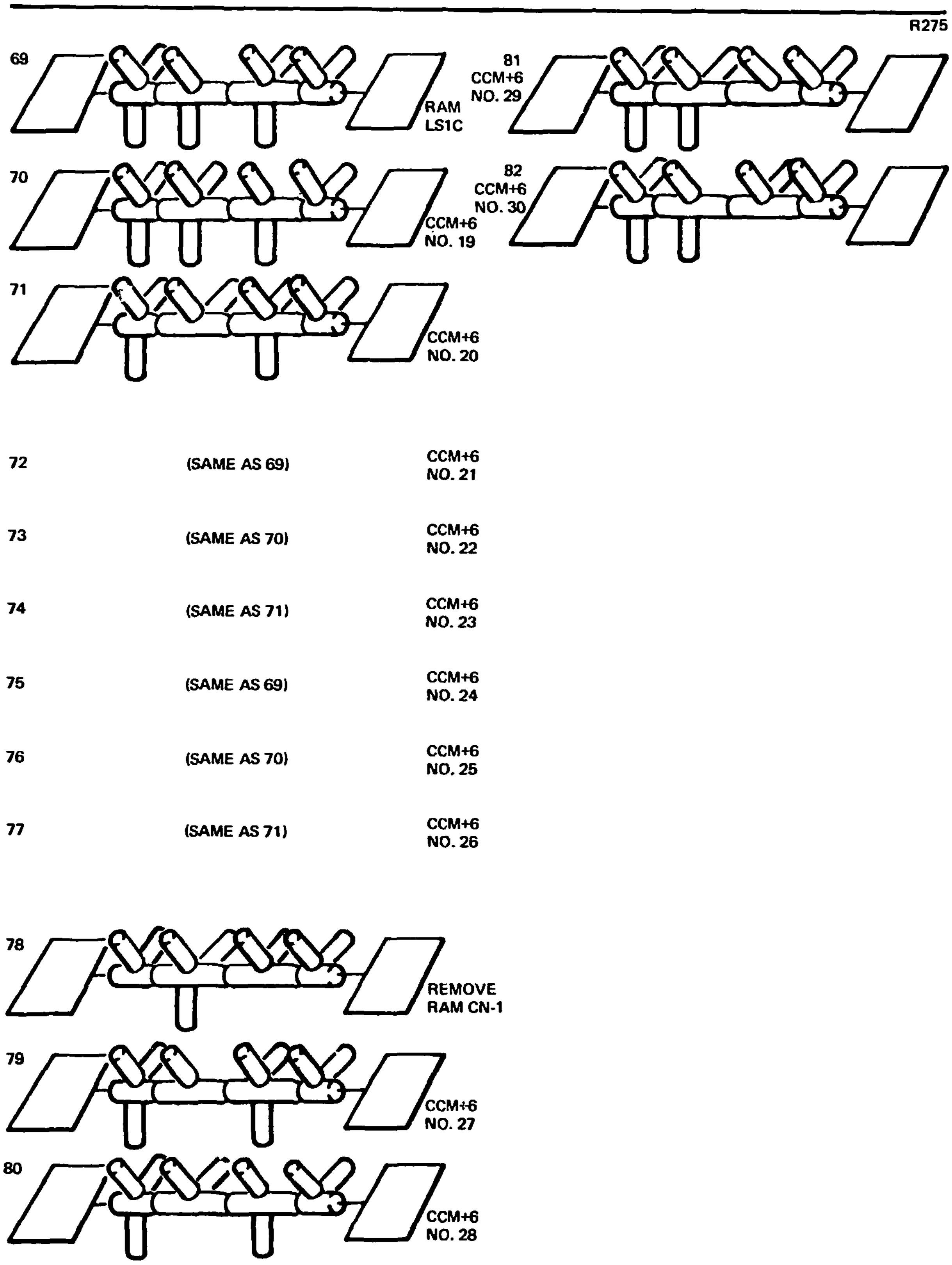


Figure 2-4. GSS Phase of Space Station Program

At step 4 in Figure 2-1, there is only one of the three docking ports on the Crew/Operations Module for the Logistics Module placement that is compatible with the experiment module placement in steps 11 and 38. The Earth-Science experiment module at step 11 as well as the Communication, Navigation experiment module desires the Earth facing position (+Z axis alignment). At step 10, the +Z axis port on the Crew/Operations Module must be vacant for the Earth-Science experiment module. The rotation of the Logistics Modules from steps 11 through 38 produce a vacant end docking port on the Crew/Operations Module so the second Crew/Operations Module can be end docked at step 39.

On reaching the GSS phase which is after the second Power/Subsystems Module is docked (step 42), the Crew Cargo Modules are docked to the ports that produce the least off-axis Crew Cargo Modules shifts and the least principal axis rotation about the pitch or Y-axis. Noting Figure 2-4, the maximum number of docking ports utilized during the GSS phase is 10 out of the 12 docking ports.

Figure 2-5 shows the axis definition of the Modular Space Station. The Station numbers are in meters and referenced to the docking port interfaces.

The physical properties of several key configurations during the buildup phase are given in Table 2-1 for the ISS and Table 2-2 for the GSS. The parameters given are mass, c.g. Station numbers, moments of inertia, and products of inertia. The moments of inertia and products of inertia are referenced to the axes shown in Figure 2-5.

The longitudinal CG excursion limits imposed by the orbiter are defined in Figure 2-6. The lateral (Y) and vertical (Z) axis limits are ±0.30 m (12 in.) about the Orbiter cargo bay centerline. All modules are within these limits which are tabulated in sections 3 and 5 for reference.

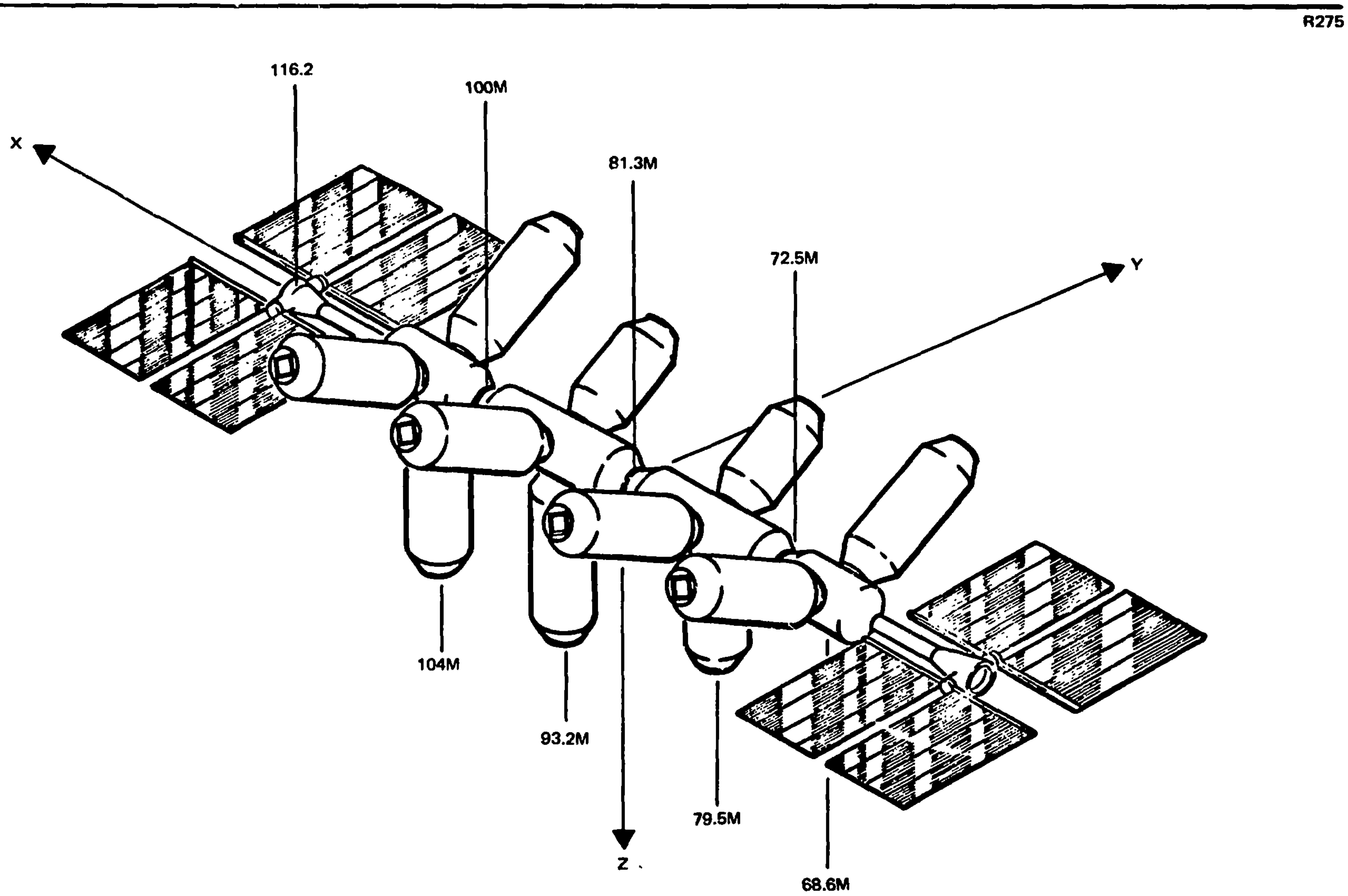


Figure 2-5. Coordinate Axes and Station Numbers

Table 2-1

MASS PROPERTIES FOR ISS BUILDUP

Flight No.	Mass ($kg \times 10^{-3}$)	CG Station (M)			Inertia ($kg\text{-}m^2 \times 10^{-6}$)					
					Moment of Inertia			Product of Inertia		
		X	Y	Z	Roll (I_x)	Pitch (I_y)	Yaw (I_z)	Yaw (I_{xy})	Pitch (I_{xz})	Roll (I_{yz})
1	9.1	108.2	0	0	0.038	0.398	0.48	0	0	0
2	18.2	100.3	0	0	0.077	1.86	1.94	0	0	0
3	27.3	97.8	-3.18	-1.68	0.77	2.02	2.39	0.438	0.228	0.217
4	36.4	97	-2.54	2.19	3.03	4.45	2.76	0.59	-0.28	0.38
5	45.4	96.2	-0.92	-0.39	1.88	2.89	3.26	0.202	0.071	0.148
6	54.5	93.3	-0.92	-1.6	1.69	5.63	6.66	0.18	0.041	0.45
10	59	97.8	-0.93	0.82	4.32	6.03	4.72	0.34	1.38	0.304
11	65.7	97.4	-0.79	3.1	6.36	8.2	4.73	0.255	0.713	0.462
12	65.7	94.8	-1.75	3.66	5.49	11.22	7.58	0.23	1.15	0.94
25	75	96.1	0.1	2.28	8.43	13.0	10.2	-0.484	0.315	1.35
27	75	98.1	0.01	-0.58	7.73	7.65	7.37	0.658	-0.914	-0.418
28	75	95.8	-0.71	-0.01	7.26	11.26	10.66	0.847	-1.105	-0.23

Table 2-2

MASS PROPERTIES FOR GSS BUILDUP

Flight No.	Mass ($kg \times 10^{-3}$)	CG Station (M)			Inertia ($kg\text{-}m^2 \times 10^{-6}$)					
					Moment of Inertia			Product of Inertia		
		X	Y	Z	Roll (I_x)	Pitch (I_y)	Yaw (I_z)	Yaw (I_{xy})	Pitch (I_{xy})	Roll (I_{yz})
37	65.7	94.8	-3.34	0.97	4.52	9.93	7.81	0.896	-0.467	-0.33
39	77	94.6	0.895	-0.1	5.38	10.6	9.85	-0.65	-0.73	1.26
40	77	92.5	-1.48	0.36	5.37	12.4	10.8	0.572	0.147	-1.54
42	88.5	90.6	0.79	-0.076	5.71	20.1	19.3	-0.657	-0.76	1.53
44	100	89.3	-0.5	-0.076	6.06	21.1	19.8	0.33	0.102	-1.67
45	109	87.6	0.63	-0.71	8.35	25.3	25.2	-0.57	1.44	-4.1
52	127	86.1	0.05	2.06	11.1	34.4	30.8	-0.44	1.95	-4.42
54	127	85.7	0	-0.33	9.6	34.3	34.1	-0.33	1.79	-2.8
61	136	35.2	0.41	-0.076	11.95	35.8	35.9	-1.02	0.72	1.4
66	145	88	-0.89	1.27	12.8	38	34.8	0.335	-0.38	2.65
69	145	86.9	-0.025	0.13	14.5	38.2	36.9	-0.78	3.38	0.58

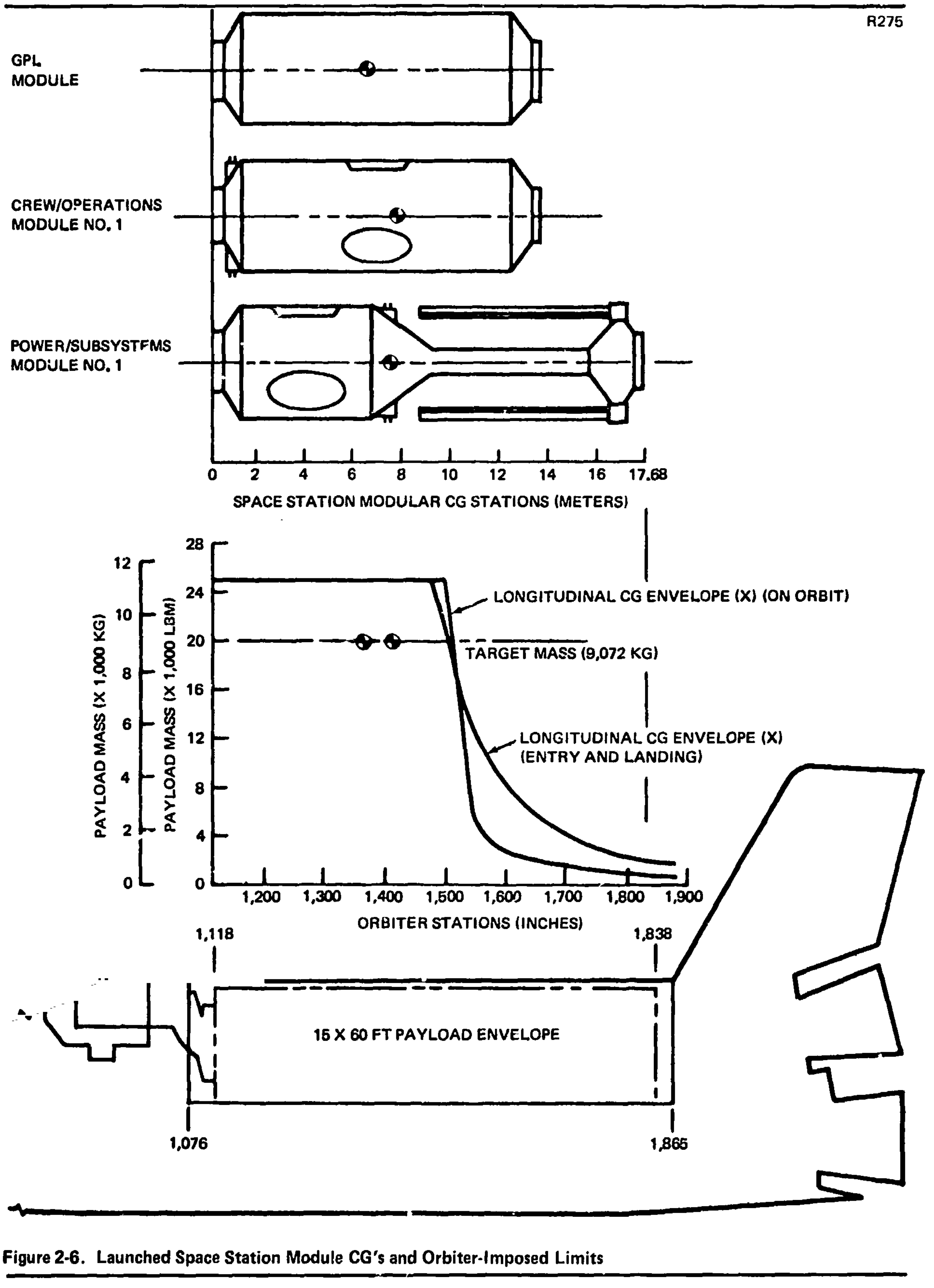


Figure 2-6. Launched Space Station Module CG's and Orbiter-Imposed Limits

Section 3

BASELINE INITIAL SPACE STATION MODULE CONFIGURATION

The mass properties presented in this section are more detailed than those in the previous sections. They include only the ISS modules: Power/ Subsystems, Crew Operations, and GPL. The GSS is covered in Section 4 and the Logistic Module is summarized in Section 4. The detail substantiation for the ISS Modules is included in Section 7.

3.1 ISS INBOARD PROFILE

Figure 3-1 is an inboard profile of the Baseline ISS Configuration and relates the on orbit longitudinal (X) stations. Figure 3-2 through 3-4 give added detail to the interiors as well as equipment locations.

3.2 ISS SUMMARY OF REASONS FOR MASS CHANGE

Tables 3-1 presents a summary of the mass changes.

3.3 ISS MODULES MASS PROPERTIES SUMMARY

The Space Station modules detailed mass and CG values are summarized in Table 3-2 to the second-generation functional code level. Module moments and product of inertia are noted in Table 3-3.

3.4 INVENTORY OF FLUIDS AND PROPELLANTS LOADED

Table 3-4 summarizes the current inventory of fluids and propellants as loaded on the initial launch masses. Added definition and qualities of the logistic options are contained in Section 6. The Logistic program is documented in SE-06.

3.5 CRITICAL MASS PROPERTIES

Current baseline is well within all mass properties limits. See Table 3-2.

3.6 POTENTIAL IMPROVEMENTS

A list of potential weight improvements are noted in Table 3-5.

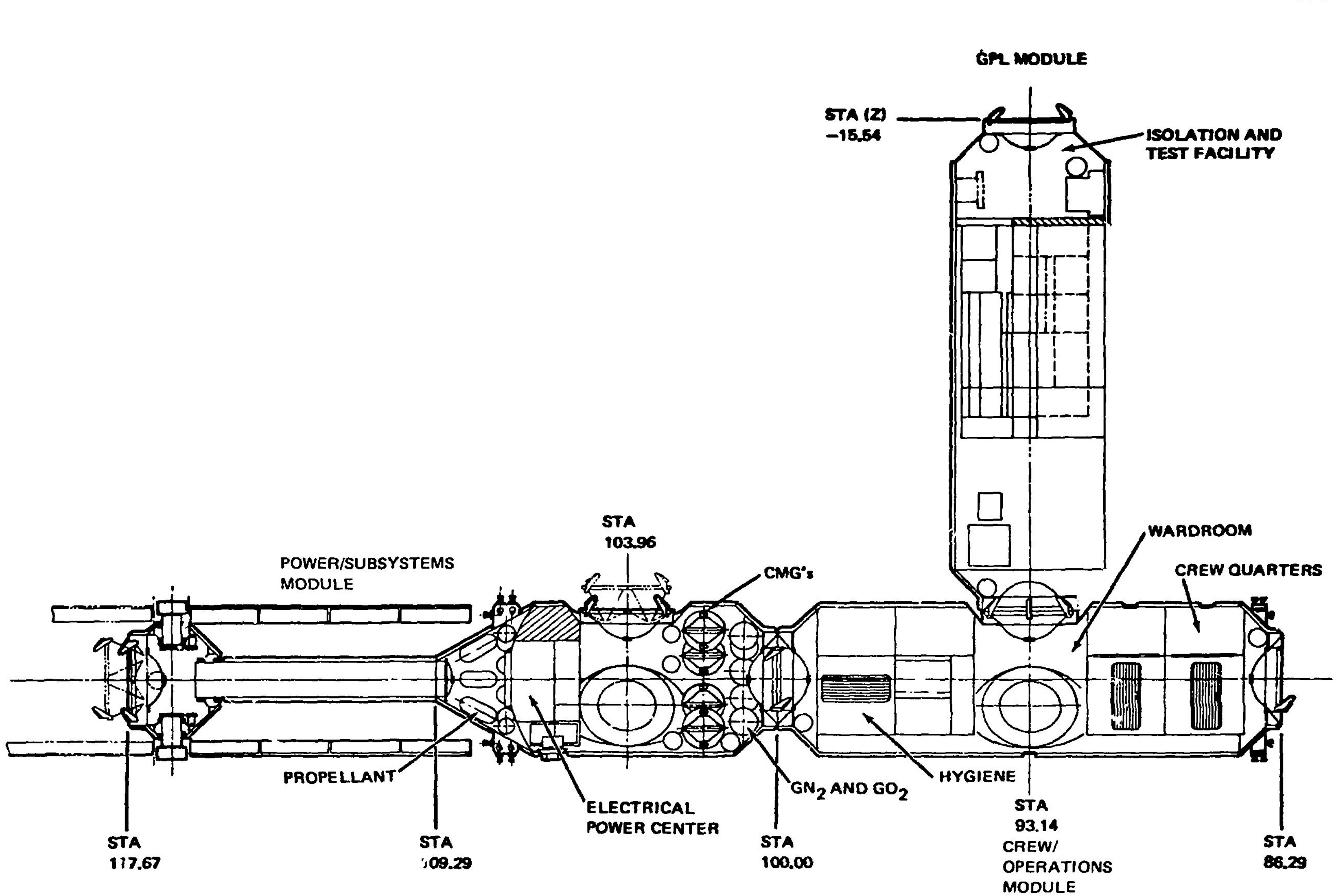
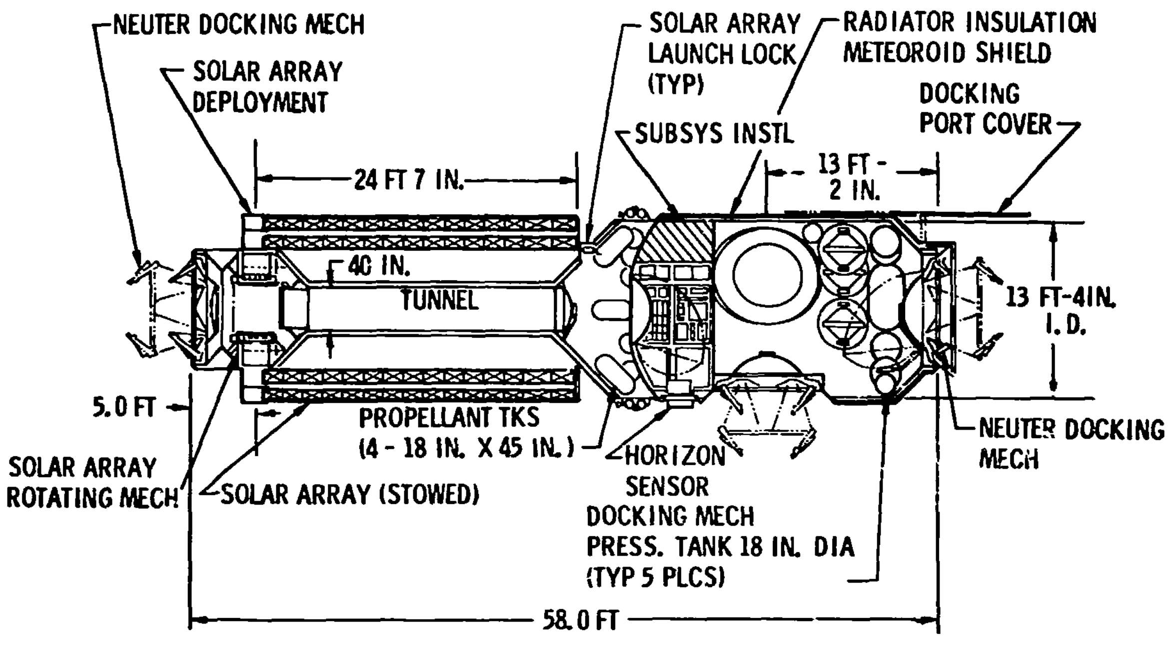


Figure 3-1. ISS Inboard Profile



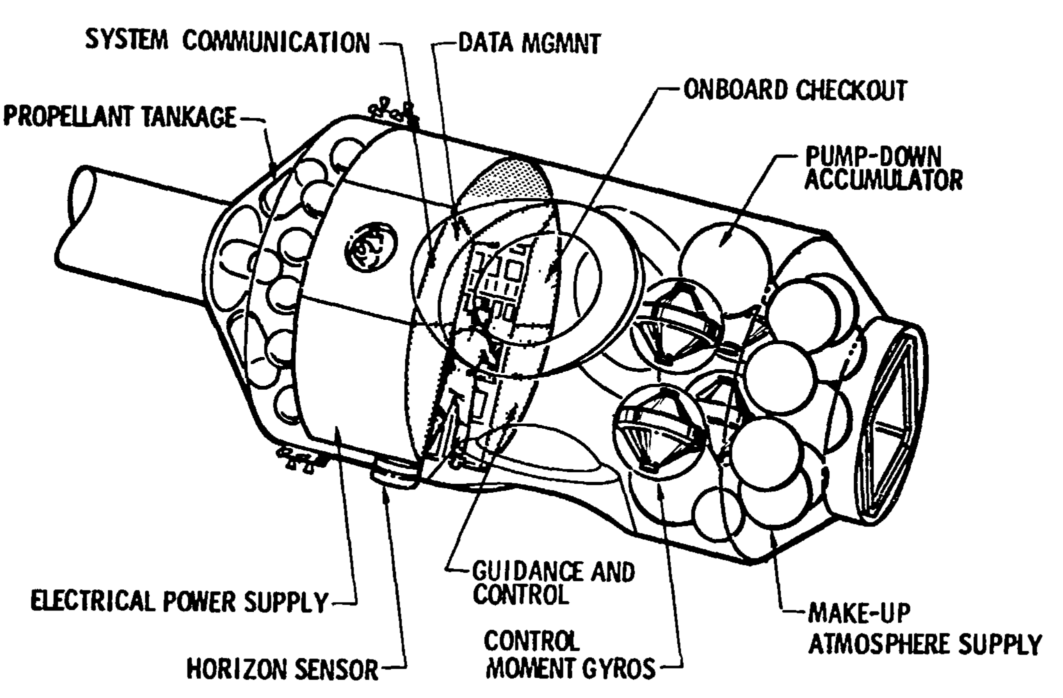
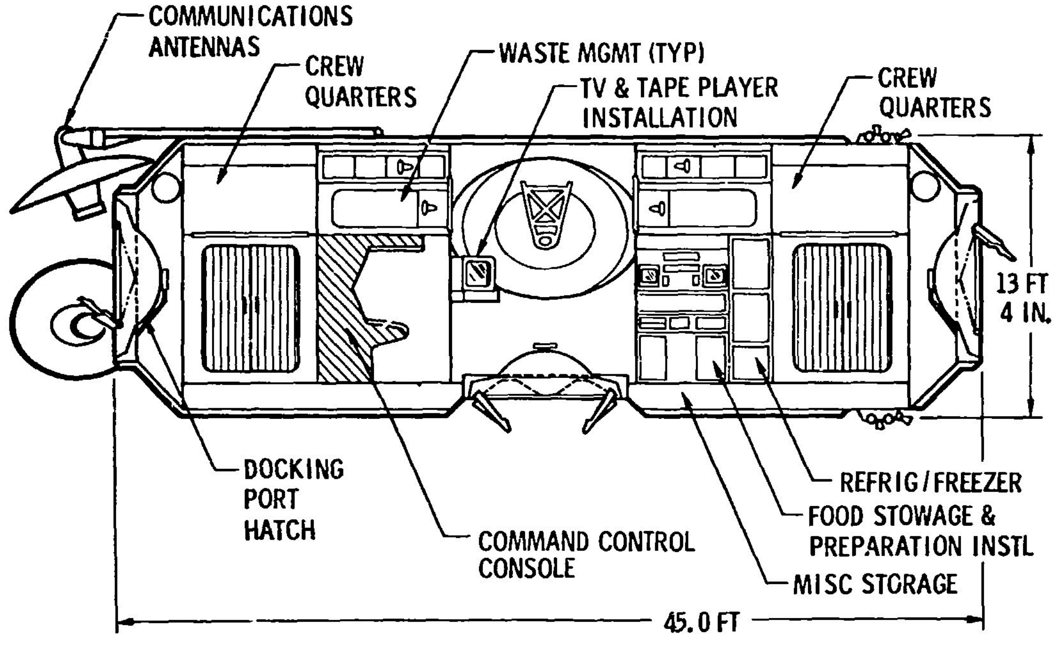


Figure 3-2. Power Module

R275



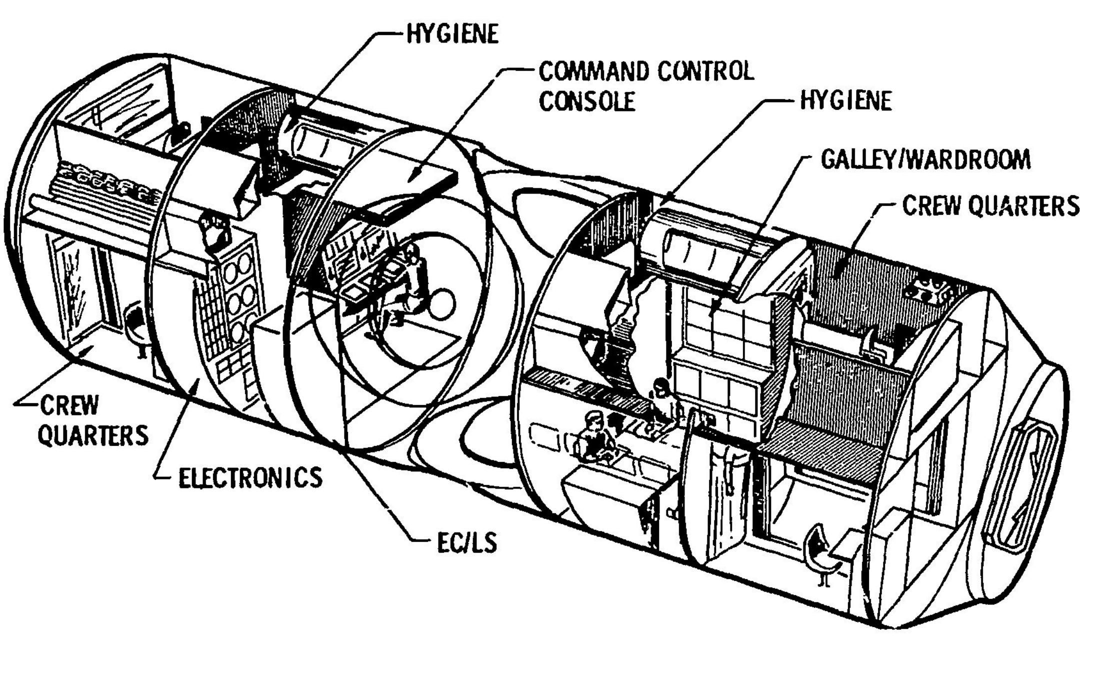


Figure 3-3. Crew Module

R275

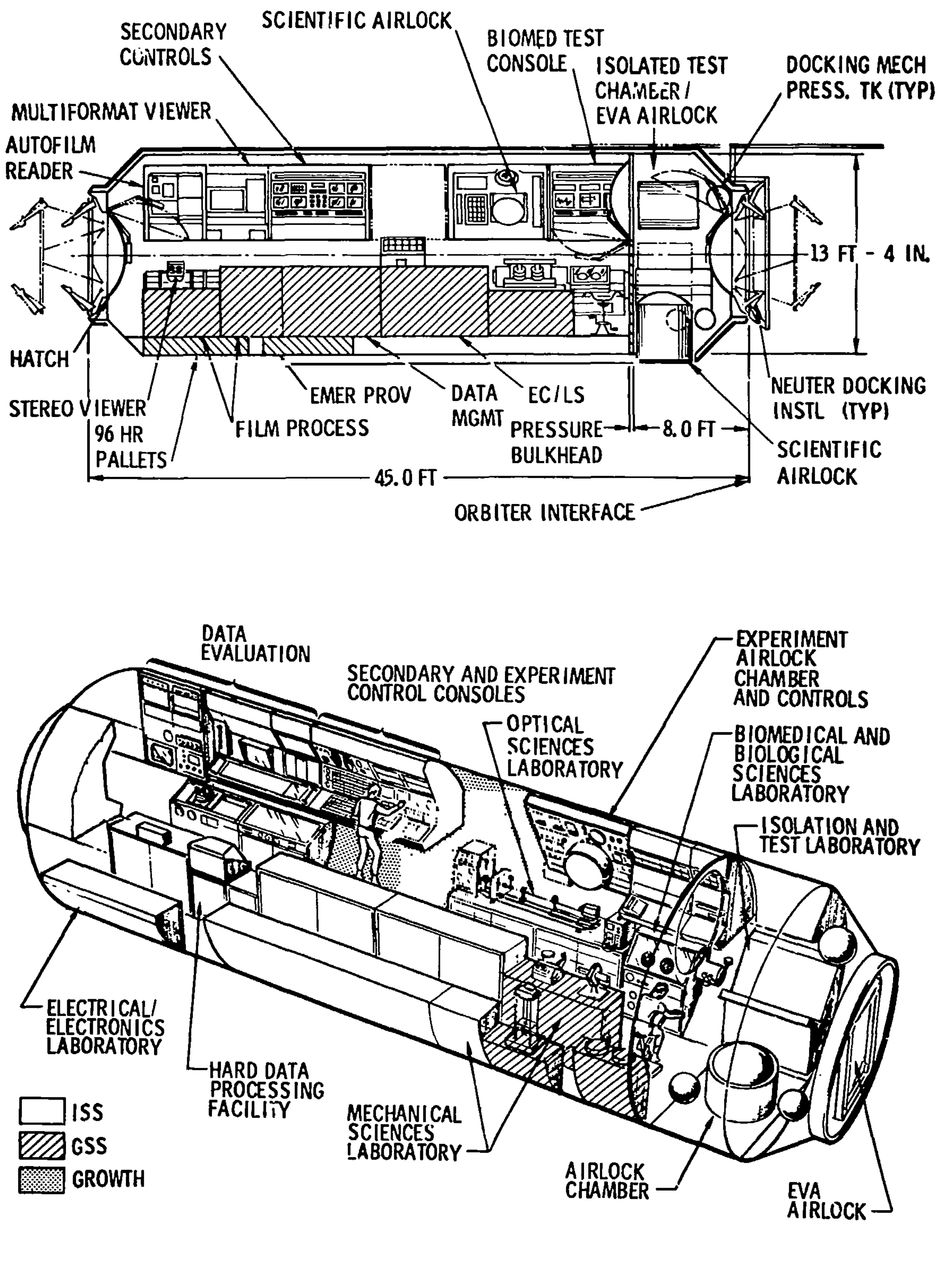


Figure 3-4. General Purpose Laboratory Module

Table 3-1

SUMMARY OF REASONS FOR CHANGES

Code	Description	Mass Change (kg) Power Subsystems	Mass Change (kg) Crew/ Operations	Mass Change (kg) GPL	Reason for Change
02.00	Structure	-179	-233	-379	
		-156	-156	-156	Functional code transfer of end docking interface structure (2) from skirts.
		- 89	- 76	-179	Complete update of sidewall to reflect current increased definition of baseline design
		+ 27	--	--	Update of turret and tunnel to reflect latest design.
		+ 36	+ 63	+ 59	The equipment support structure was updated to reflect 4.5 percent of the maximum equipment within the modules.

Table 3-1

SUMMARY OF REASONS FOR CHANGES (Continued)

		Mass Change (kg)			
Code	Description	Power Subsystems	Crew/ Operations	GPL	Reason for Change
		- 10	- 20	- 20	The skirts were also revised to reflect latest estimates and elimination of duplicated ring masses.
		--	--	- 67	Incorporation of new GPL structural analysis of pressure floor.
		+ 13	.. 44	- 16	Miscellaneous revisions.
03.00	Meteoroid and Thermal Protection	+161	+ 98	+ 97	
		+133	--	--	Functional code transfer of solar collectors from thermal control (FC 12.03)
					Updated estimate of the following to reflect current design.
		+ 53	+ 80	+ 84	Radiator
		- 10	+ 13	- 2	Insulation

Table 3-1

SUMMARY OF REASONS FOR CHANGES (Continued)

		Mass Change (kg)			
Code	Description	Power/ Subsystems	Crew/ Operations	GPL	Reason for Change
		+ 4	+ 4	+ 4	Thermal Coating
		- 19	+ 1	+ 13	Meteoroid Protection
04.00	Docking Provisions	+ 27	+ 27	+ 97	
		+156	+156	+156	Function code transfer of interface structure (FC 02.00). Complete update of docking structure based on detailed mass estimate.
		+ 5	+ 5	+ 2	Ring assembly (-1 kg/each)
		- 10	- 10	- 10	Shock absorber (-2 kg/each)
		- 80	- 80	- 32	Latches (- 16 kg/assembly)
		- 5	- 5	- 5	Hydraulic and seal provisions
		- 20	- 20	- 8	Structural interface rings
		- 19	- 19	- 11	Miscellaneous

Table 3-1

SUMMARY OF REASONS FOR CHANGES (Continued)

Code	Description	Mass Change (kg) Power/ Subsystems	Crew/ Operations	GPL	Reason for Change
		- 16			The drive assembly was revised using structural sketches.
		- 44			Gross contingency allowance was removed upon completion of detailed mass estimates of solar array subsystem.
		- 12			Miscellaneous
08.00	Power Conversion	- 35	- 15	- 26	
		- 11	- 5	- 16	Removal of support structure allowance as this is included in the structure code (FC 02.11).
		- 24	- 10	- 10	Miscellaneous items.

Table 3-1

SUMMARY OF REASONS FOR CHANGES (Continued)

Code	Description	Mass Change (kg) Power/ Subsystems	Crew/ Operations	GPL	Reason for Change
06.00	Propulsion	- 61	- 60	- 23	Previous estimate was based on parametric values for a 1,000 lb of N_2H_4; current estimate is for 753 lb (342 kg) with detail estimates for the total system.
07.00	Prime Power	-226	--	--	
		- 35			The Solar Array Blanket contingency was reduced from 10 percent to 5 percent to reflect increased design definition.
		- 65			The astro mast contingency was removed as current design is sized for an artificial gravity mode and is considered conservative.
		- 54			The quadrant container was also revised to reflect the reduced length of the baseline design.

Table 3-1

SUMMARY OF REASONS FOR CHANGES (Continued)

Code	Description	Mass Change (kg)			Reason for Change
		Power/ Subsystems	Crew/ Operations	GPL	
10.0	Vehicle Electronics	- 2	-125	- 98	
		--	- 35	--	The experiment alignment monitor was deleted from program in cost savings.
		- 3	- 3	- 3	Docking reflectors were also deleted, as orbiter has the necessary features.
		--	--	-147	The image processing equipment have been included in logistic options.
		+ 9	- 9	--	Input/output controller moved to power module.
		--	- 79	--	Update of High-Gain Antenna system by subcontractor.
		- 8	+ 1	+ 4	Miscellaneous

Table 3-1

SUMMARY OF REASONS FOR CHANGES (Continued)

Code	Description	Mass Change (kg) Power/ Subsystems	Crew/ Operations	GPL	Reason for Change
11.0	Wiring	-149	-248	-173	Update of wiring estimate plus reduction of contingencies (30 percent to 10 percent).
12.00	Atmoshpere and Thermal Control	-161	- 25	-121	
		- 65	- 49	-105	Quantity of cold plates has been reduced plus an update of the equipment thermal control subsystem.
		-145	--	--	Solar collectors were revised (-12 kg) and then recorded to Active Thermal Control (FC 03.01) (-133 kg)
		+ 36	+ 33	+ 33	Non-optimum added to radiator thermal control to account for lack of details.

Table 3-1

SUMMARY OF REASONS FOR CHANGES (Continued)

Crew	Description	Mass Change (kg) Power/ Subsystems	Crew/ Operations	GPL	Reasons for Change
		+ 13	- 9	- 7	Miscellaneous
		--	--	- 42	Removal of support structure, carried in structure (FC 02.11).
14.00	Crew Life Support and Furnishings	+ 15	- 91	+ 3	
		--	- 20	--	Removal of support structure, included as part of Structure (02.11).
		+ 15	- 71	+ 3	Interior provisions originally were estimated on parametric values, current estimates are based on inboard profile drawings, plus miscellaneous changes.
17.00	Crew Equipment	- 11	- 80	- 11	All crew equipment has been moved to logistic options.

Table 3-1

SUMMARY OF REASONS FOR CHANGES (Continued)

Code	Description	Mass Change (kg) Power/ Subsystems	Crew/ Operations	GPL	Reason for Change
18.00	GPL Provisions	--	--	-432	Data evaluation equipment plus misc GPL items were made logistic options.
21.00	Residuals	+ 51	- 20	- 36	
		+ 35	- 58	- 58	Update of atmosphere residuals.
		- 11	+ 11	+ 11	Freon in radiator was also updated based on line lengths and components.
		+ 27	+ 27	+ 11	Incorporation of hyr fld for dock.
22.00	Reserves	--	--	--	No change.
23.00	Inflight Losses	+ 23	--	--	Added allowance for H_2H_4 resulting from update of requirements as supplied by guidance and navigation.
	Total Mass kg	-518	-722	-1102	

Table 3-2

ISS MODULE CENTER OF GRAVITY SUMMARY

Code	Description	Power/Subsystems Module No. 1				Crew/Operations Module No. 1				GPL Module			
		Mass (kg)	Center of Gravity			Mass (kg)	Center of Gravity			Mass (kg)	Center of Gravity		
			X	Y	Z		X	Y	Z		X	Y	Z
02.00	Structure	1,501	6.80	0.00	0.00	1,579	6.85	0.00	0.00	1,716	5.40	0.00	0.00
03.00	Meteoroid and Thermal Protection	956	6.03	0.00	0.00	924	6.85	0.00	0.00	908	6.85	0.00	0.00
04.00	Docking Provisions	698	5.27	0.00	0.00	698	6.85	0.00	0.00	279	6.85	0.00	0.00
06.00	Propulsion	334	7.21	0.00	0.00	143	3.86	0.00	0.00	24	6.90	0.00	0.00
07.00	Prime Power	2,098	10.33	-0.47	0.25	7	8.90	1.60	0.20	7	6.55	-1.52	1.20
08.00	Power Conditioning and Distribution	305	6.00	-1.30	0.80	130	9.75	1.60	0.20	131	7.80	-1.20	-0.90
10.00	Electronics	628	5.61	1.22	-0.53	1,145	10.97	0.15	0.12	935	8.42	-0.58	-0.17
11.00	Wiring	263	6.94	-0.59	-0.34	360	9.80	1.10	-1.10	468	5.70	0.00	0.00
12.00	Atmosphere and Thermal Control	377	6.05	0.00	-0.38	583	8.36	-0.78	0.99	571	6.57	0.00	0.61
14.00	Crew Life Support and Interiors	193	3.90	0.00	0.00	+	6.98	0.01	-0.26	302	8.12	0.00	0.00
17.00	Crew and Crew Equipment	0	1.90	0.00	0.00	0	6.80	1.60	1.00	0	4.50	0.00	0.00
18.00	GPL and Experiment Provisions	--	--	--	--	--	--	--	--	1,435	6.03	0.94	0.82
21.00	Residuals	249	4.62	0.00	0.00	310	6.80	0.00	0.00	294	6.85	0.00	0.00
22.00	Reserve	101	7.60	0.00	0.00	--	--	--	--	--	--	--	--
23.00	In-Flight Losses	240	7.60	0.00	0.00	--	--	--	--	--	--	--	--
	Subtotals	7,943	7.27	-0.09	0.03	7,043	7.81	0.05	0.01	7,070	6.51	0.09	0.18
	Discretionary Payload	1,129	7.79	-0.30	-0.04	2,029	8.05	0.26	0.28	2,002	6.18	0.22	0.28
	Target	9,072	7.343	-0.118	0.021	9,072	7.863	0.098	0.070	9,072	6.437	0.118	0.201

Table 3-3

ISS MODULE MASS PROPERTIES SUMMARY

	Mass Kg	Center of Gravity			Moment of Inertia Kg $M^2 \times 10^{-3}$			Products of Inertia Kg $M^2 \times 10^{-3}$		
		X	Y	Z	Roll (I_x)	Pitch (I_y)	Yaw (I_z)	Roll (I_{yz})	Pitch (I_{xz})	Yaw (I_{xy})
Power/Subsystem Mod.	9072	7.343	-0.118	0.021	30.3	318.5	383.4	-0.922	1.822	-3.32
Crew/OPS Module	9072	7.863	0.098	0.070	31.2	162.7	162.7	-0.415	-0.209	1.333
GPL Module	9072	6.437	0.118	0.201	30.8	161.7	161.7	1.856	-2.532	-3.16

Logistics Module
included in Section 5.

Products of inertia equations:

$$\text{Yaw } (I_{xy}) = \sum I_{o_{xy}} + \sum wxy - W \bar{x} \bar{y}$$

$$\text{Roll } (I_{yz}) = \sum I_{o_{yz}} + \sum wyz - W \bar{y} \bar{z}$$

$$\text{Pitch } (I_{xz}) = \sum I_{o_{xz}} + \sum wxy - W \bar{x} \bar{z}$$

FOLDOUT FRAME |

Table 3-4

INVENTORY OF ISS MODULE PROPELLA[illegible]
AND FLUIDS LOADED FOR INITIAL LAU[illegible]

Code	Description	Power Module*				Crew Modul[illegible]		
		Inflight Losses (23.00)	Reserves (22.00)	Residuals (21.00)	Total	Inflight Losses (23.00)	Reserves (22.00)	Res (21.
21.01	GN_2	--	--	14	14	--	--	-
21.03 22.00 23.00	N_2H_4	101	240	19	360	--	--	-
21.13	H_2O	--	--	6	6	--	--	
21.13	Freon	--	--	39	39	--	--	5[illegible]
21.13	Atmosphere (GN_2)	--	--	105	105	--	--	16[illegible]
21.13	Atmosphere (GO_2)	--	--	39	39	--	--	5[illegible]
21.13	Hydraulics	--	--	27	27	--	--	27
	Totals	101 (233 lbm)	240 (530 lbm)	249 (549 lbm)	590 (1,302 lbm)	--	--	31[illegible] (684 lb[illegible]

*Units is kg, unless otherwise indicated.

FOLDOUT FRAME 2

Table 3-4

NVENTORY OF ISS MODULE PROPELLANTS
ND FLUIDS LOADED FOR INITIAL LAUNCH

*		Crew Module				GPL Module			
iduals (. 00)	Total	Inflight Losses (23. 00)	Reserves (22. 00)	Residuals (21. 00)	Total	Inflight Losses (23. 00)	Reserves (22. 00)	Residuals (21. 00)	Total
14	14	--	--	--	--	--	--	--	--
19	360	--	--	--	--	--	--	--	--
6	6	--	--	6	6	--	--	6	6
39	39	--	--	58	58	--	--	58	58
05	105	--	--	160	160	--	--	160	160
39	39	--	--	59	59	--	--	59	59
27	27	--	--	27	27	--	--	11	11
49 49 m)	590 (1, 302 lbm)	--	--	310 (684 lbm)	310 (684 lbm)	--	--	294 (648 lbm)	294 (648 lbm)

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Table 3-5

SPACE STATION IMPROVEMENT POTENTIALS

Code	Description	Approximate Mass Savings (kg)		
		Power/ Sub-system	Crew/ Oper-ations	GPL
02.00/ 06.00 21.00/ 22.00	Fly minimum propellant orientation during buildup; would decrease propellant, support structure, tankage, and reserve	-282		
03.00	Design for a ΔT drop of 4°F instead of 2°F to permit reduced web thickness	- 72	-132	-132
03.00	Meteoroid tests confirm a increased efficient factor which permits a reducing in shielding thickness on radiator tubes	- 52	- 75	- 75
07.00	Redesign of astro-mast to reflect zero-G loading and decreased array size	-135		
07.00	Incorporation of a dc-dc converter would permit two batteries to be used in place of the current four (one set)	-358		
14.00	Removal of some partitions and furnishings gear as logistic options		-240	
14.00	Design crew support provisions, such as ovens, washer/dryer, as potential logistic options		- 91	
	Total	-899 (-1,982 lbm)	-538 (-1,186 lbm)	-207 (-456 lbm)

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Section 4
GSS MODULE CONFIGURATION

The GSS is nominally planned for operation in the sixth year of a 10-year mission. The ISS modules are then supplemented with a second Crew/Operation Module and a second Power/Subsystem Module. These two modules are identical to their ISS counterparts except for those additional items noted.

Subsystem equipment additions for the GSS to accommodate free flying experiment modules are required for:

A. Module checkout, monitoring, and navigation updates.
B. Communications for flight control, experiment command, and tracking.
C. Experiment data transfer via RF link.
D. Computer and data storage services for control and experiment processing.
E. Rendezvous and docking control.
F. Housekeeping support while docked.
G. Replenishment of subsystem consumables; e.g., propellant.

The added subsystem equipments for experiment support are listed in Table 4-1 and include assembly mass estimates. The total addition for FFM operation is nominal with the chief additions being needed for communications/tracking, and docking operations. The propellant required per month is reported for the peak usage and is supplied from the Logistic Module "pantry." The necessary plumbing and controls for propellant transfer exist at each docking port interface; thus, the requirement is simply one of logistic supply.

The communications subsystem will require addition of a medium gain antennas mounted on the solar array—turret drive on the second power

Table 4-1

SUBSYSTEMS EQUIPMENTS TO ACCOMMODATE FREE-FLYER EXPERIMENT MODULES – GSS

Subsystem	Description	kg	Mass (lbm)
Guidance, navigation, and control	Docking alignment aids (lights)	1	2
	Rendezvous tracker	18	39
Propulsion	Pressurant and propellant	155	342/mo
Communications	Medium-gain antenna	18	40
	K_u-band power amplifier	5	10
	K_u-band exciter	1	3
	K_u-band receiver	2	5
	S-band data receivers	41	90
	S-band video receivers	15	32
DMS/OBC	16K digital storage/software	9	20
Display/Control	Portable display and control with flight control plug-in	45	100
	Reticule telescope (two)	5	10
	Displays for tracking/control	23	50
EC/LS Power	None		
	Total	183*	401*

*Excluding propellant resupply.

module. From this vantage point, the tracking and communications equipments will have unobstructed view of the FFM's in their flight patterns behind the GSS. A dedicated display panel will be located in the GPL and will be used to track and monitor the modules.

Rendezvous and docking operations will require addition of the laser radar, a portable display and control unit with flight controls, and a reticule telescope. The telescope will be mounted at the viewing window in the center of the docking port and, after alignment, will be used in conjunction with the portable controls to fly the modules. It should be noted that the operations are are similar to those used on the Orbiter during Orbiter/Station docking and are GSS additions since the ISS is passive during normal Orbiter docking.

Equipment not required in the second Crew/Operations module include only the high-gain antennas (247kg/546 lbm). The initial launch mass of the Power/Subsystems module could be reduced by removal of the propellant (342 kg/753 lbm) in the propulsion tankage and then later resupplying if other logistic options were desired.

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Section 5
BASELINE LOGISTIC MODULE CONFIGURATION

The Baseline Logistic Module contains no active subsystems, as either the Shuttle Orbiter or Space Station supplies all its subsystem requirements. The Logistic Module is also direct-docked to the Station, as it contains no onboard propulsion system. This section represents the formal documentation in accordance with MIL-M-38310A. Weight substation and methodology is noted in Section 7 for the ISS Modules and the Logistic Modules shares common design.

5.1 INBOARD PROFILE

Figure 5-1 is the inboard profile of the Logistic Module. Basically, it is 8.5 m (28 ft) in length with neuter docking at each end. In addition to the cargo area, a two-man EVA airlock is provided between the cargo bay and the orbiter.

5.2 SUMMARY OF REASONS FOR CHANGES

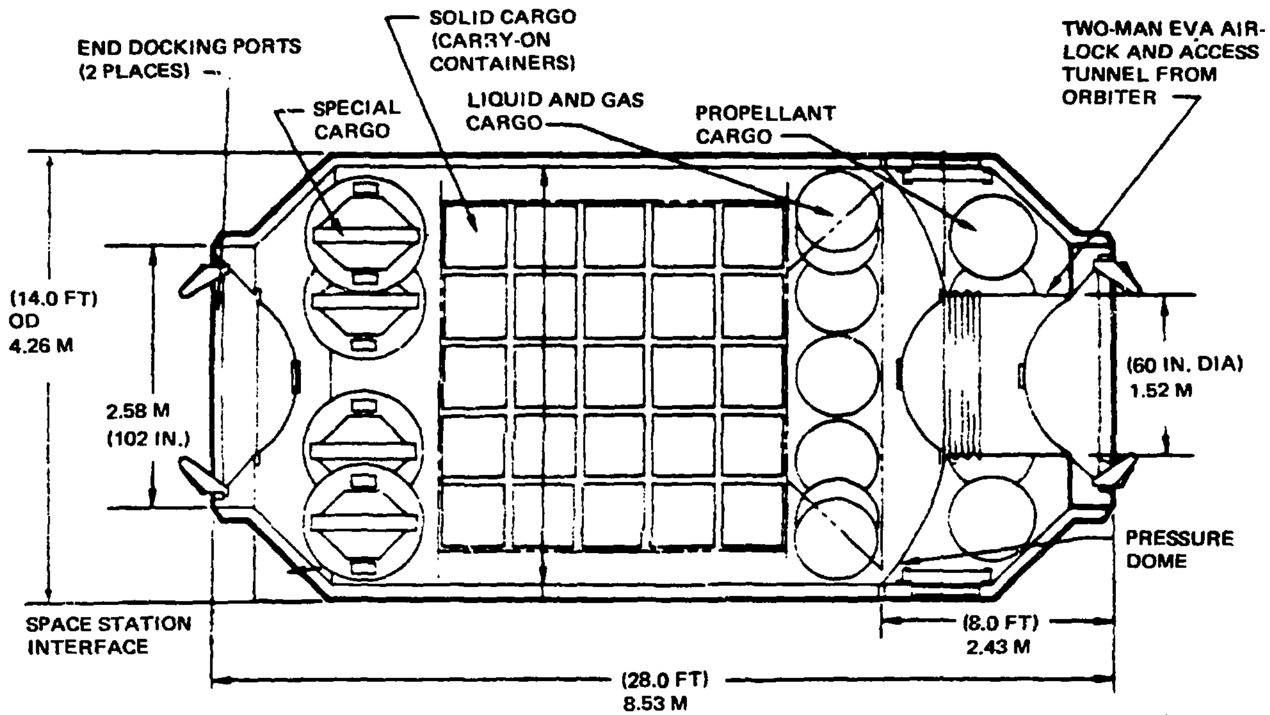
The major mass properties changes includes incorporation of three high pressure gaseous O_2 bottles (236 kg) and a gaseous N_2 bottle (77 kg) in the dry mass. There were a variety of miscellaneous changes which were basically updated for the remaining net change of -28 kg.

5.3 LOGISTIC MODULE MASS PROPERTIES SUMMARY

Table 5-1 presents the mass properties summary of the Logistic Module. The Logistic Module has a mass of 3,011 kg (6638 lbm), and the combination of Logistic Module and that cargo required for the first launch is 8,006 kg (17,652 lbm), well below the 9,072-kg (20,000-lbm) target.

5.4 INVENTORY OF FLUIDS AND PROPELLANTS LOADED

These data are included in the pertinent subsystem and detailed in Sections 6 and 7. Those required in the first Logistic Module flight are listed in this section for reference (see Table 5-2).



CENTER OF GRAVITY (METERS)			MOMENTS OF INERTIA $KgM^2 \times 10^{-3}$			PRODUCTS OF INERTIA $KgM^2 \times 10^{-3}$		
X	Y	Z	ROLL (I_X)	PITCH (I_Y)	YAW (I_Z)	ROLL (I_{YZ})	PITCH (I_{XZ})	YAW (I_{XY})
4.47	0.0	0.0	31.0	101.1	101.1	1.16	-1.59	-1.97

Figure 5-1. Logistic Module Inboard Profile

Table 5-1

LOGISTIC MODULE

Code	Description	Mass (kg)		Mass (lbm)	
02.00	Structure	1,200		2,647	
02.10	Unpressurized compartment		0		0
02.11	Pressurized compartment		1,183		2,609
02.15	Finish, seals, and spares		17		38
03.00	Meteoroid and thermal protection	501		1,104	
03.02	Passive thermal protection		155		342
03.04	Meteoroid protection		346		762
04.00	Docking provisions	279		616	
04.05	Docking structure		279		616
06.00	Propulsion	72		158	
06.07	Fuel container		14		30
06.09	Pressurization and control		23		50
06.10	Fuel distribution and control		6		13
06.14	Umbilical		14		30
06.15	Support structure		15		35
08.00	Power conditioning and distribution	35		77	
10.00	Electronics	207		456	
10.01	Guidance and control		3		7
10.02	Onboard checkout		103		227
10.03	Data management		28		61
10.06	Communication		29		64
10.15	Displays and controls		44		97
11.00	Wiring	75		165	
12.00	Atmosphere and thermal control	336		740	
12.02	Atmosphere control and supply		336		740
14.00	Crew life support and interiors	197		435	
14.01	Hand rails and restraints		31		69
14.03	Cargo handling		23		51
14.04	Interior furnishings		143		315
21.00	Residuals	109		240	
21.13	Other residuals		109		240
	Total	3,011		6,638	

Table 5-2

INVENTORY OF FLUIDS AND GASES WITHIN FIRST LOGISTIC FLIGHT

		Residuals (kg)	Reserves (kg)	In-flight Losses (kg)	Total (kg)
21.13	Hydraulics	11			10
21.13	Atmosphere GO_2	23			23
21.13	Atmosphere GN_2	76			76
[1]	Cargo (Firstlogistics module)				
12.02	Repressurization (GO_2)		65		65
12.02	Repressurization (GN_2)		218		218
12.02	Metabolic reserve (GO_2)		53		53
23.00	Propellant (N_2H_4)			50	50
23.00	Pressurant (GN_2)			14	14
[2]	Metabolic (60 MD)			116	116
14.02	H_2O (contingency) (60 MD)		90		90
[3]	96-hour pallet (9 mandays)				
12.02	Metabolic (GO_2)		24		24
12.02	H_2O		41		41
	Totals	109 (240 lbm)	491 (1,082 lbm)	180 (397 lbm)	780 (1,720 lbm)

[1] Section 6 for total buildup logistics.

[2] Bleed into Space Station as needed (1.94 lb/man-day) (FC 12.02).

[3] Three supplied on Initial Logistic Flight.

Section 6
LOGISTICS AND LOGISTIC OPTIONS

The baseline Space Station has maximized the discretionary payload available for growth and the resulting minimum launch weight by transporting some equipment and expendables in the Logistic Modules. Candidate logistic options are defined as those that are not mission-critical during activation and are either designed for periodic replacement or have a simple installation interface. With the current margins not all logistic candidates need be logistic supplied, example could be the CMG's which may be launched in the power module if desired.

6.1 POWER/SUBSYSTEM MODULE LOGISTICS AND OPTIONS

Table 6-1 summarizes the logistic options for the Power/Subsystems Module. It should be noted that logistic options are often only a portion of a certain capability. For example, sufficient propellant is onboard for the 90 days of buildup plus a 30-day contingency supply. Half the batteries (four) are logistic options, since the power requirements during buildup are low. Makeup atmosphere is also included onboard, although complete repressurization is considered an acceptable option prior to manned operation. A portable checkout unit is included for use by the activation crew if needed.

6.2 CREW/OPERATIONS MODULE LOGISTICS AND OPTIONS

Table 6-2 summarizes the logistics and logistic options necessary for an initial two-man crew. The second logistic module supplies an additional two crewmen and second set of crew-related contingency supplies, plus the nominal usage for four men. This is repeated with the third logistic module for a total crew of six men.

The crew module houses all stocked spares necessary for a random failure except those for GPL equipment. The initial spares noted in Table 6-3 are sufficient for a 120-day supply with a breakout by subsystem.

Table 6-1

POWER MODULE LOGISTIC AND OPTIONS

Code	Description	Logistic Module Mass (kg)		
		1	2	3
06.00	Propulsion			
	Bio waste tanke (2)	18	--	--
07.00	Prime power			
	Torque tube	10	--	--
	Batteries	--	725	--
10.00	Vehicle electronics			
	CMG's and electronics (5)	734	181	--
	Attaching parts	5	--	--
	DM computers (2)	18	--	--
	Portable checkout display units	45	--	--
12.00	Atmosphere and thermal control			
	*Repressurization O_2 (1)	133	--	--
	*Repressurization N_2 (3)	480	--	--
	*Metabolic O_2 reserve (3)	109	109	109
	Pump-down accumulators (2)	--	38	--
	96-hour pallet (1)	345	--	--
17.00	Crew equipment			
	Fire extinguisher	11	--	--
23.00	In-flight losses			
	Propellant (N_2H_4)	50	50	50
	Pressurant (GN_2)	14	14	14
	Total mass	1, 972	1, 117	173
		(4, 347 lbm)	(2, 463 lbm)	(381 lbm)

Table 6-2

CREW MODULE LOGISTIC AND OPTIONS

Code	Description	Logistic Module Mass (kg)		
		1	2	3
02.00	Structure			
03.00	Meteoroid/thermal provisions	23	12	10
04.00	Docking provisions			
	Spares			
06.00	Propulsion			
	Spares	33	16	17
07.00	Prime power			
	Spares	30	15	15
	Batteries	725	725	--
08.00	Power conditioning and distribution			
	Spares	30	15	15
10.00	Electronics			
	OBCO and data management spares	51	26	25
	Guidance and control spares	34	17	16
	Communcation spares	37	18	18
12.00	Atmosphere and thermal control			
	Spares	183	94	90
	96-hour pallets (2)	--	345	345
14.00	Crew life support and furnishings			
	Spares	34	17	17
	Utensils	17	--	--
	Food (nominal)(60 MD)(120 MD)(180 MD)	80	160	240
	Freezer (1)	18	--	--
	Refrigerator (1)	17	--	--
	Dry stowage (2)	16	16	--
	Housekeeping	30	21	--
	Dryer (1)	27	--	--
	Compactor (1)	73	--	--
	Canister (12)	15	30	36
	Liners	8	--	--
	Bunks (6)	5	5	5
17.00	Crew equipment			
	Personal hygiene (6)	3	3	3
	Garments	11	10	10
	Portable life support units (2)	47	47	--
	O_2 mask (6)	3	3	3
	IVA/EVA life support (2)	21	21	--
	IVA support (1)	5	--	--
	Pressure suits (spares) (6)	9	9	--
	Medical provisions	45	--	--
	Recreation gear	57	57	57
	Fire extinguishers	11	--	--
	Total mass	1,698 (3,743 lbm)	1,682 (3,708 lbm)	922 (2,033 lbm)

Table 6-3

TOTAL INITIAL SUBSYSTEM SPARE WEIGHTS

	Spares (120 Days) Mass	
Subsystem	kg	lbm
Electrical power[1]	120	265
EC/LS	367	810
Guidance, navigation, and control[2]	249	549
Data management and onboard checkout	102	225
Propulsion	66	145
Communications	73	160
Structure mechanical	45	99
Crew habitability	68	150
GPL support	91	201
Totals	1,181 kg	2,604 lbm

NOTES:

1 Includes three battery modules (50 lb/each).

2 Includes a CMG (400 lb).

Structures was selected to illustrate the detail components (Table 6-4) of the previous table. Added details on these items can be found in document MP-01.

6.3 GPL MODULE LOGISTICS AND OPTIONS

The majority of initial logistic options for the GPL include the support equipment and can be supplied on a payload-available basis. Table 6-5 is a summary of these items. Also included are the contingency food (180 man-days) and contingency water. In Section 7 all the logistic options are shown as compared to the initial launch quantity.

6.4 SUMMARY OF INITIAL BUILDUP LOGISTICS AND OPTIONS

Table 6-6 summarizes the logistics and options required for the 6 man manning which is arrived at with the first three logistic modules. After this buildup phase the logistic launches are used only to supply continuing on-orbit operations. Added definition and details are available in SE-06 on these flights.

Table 6-4

INITIAL STRUCTURE/MECHANICAL DETAIL SPARE WEIGHTS

Number of Spare Parts	Part Title	Cumulative Weight	
		kg	lbm
1	Hydraulic dock port door seal	0.227	0.5
1	Hydraulic lines/strut leak	0.680	1.5
1	Airlock door seal	0.816	1.8
1	Viewport seal	0.907	2.0
1	Airlock door viewseal	0.998	2.2
2	Dock port door seal	1.225	2.7
1	Hydraulic lines	2.132	4.7
2	Hydraulic lines/strut leak	2.586	5.7
1	Docking structure kit	3.720	8.2
1	Meteoroid/hole patch kit	3.992	8.8
1	Docking strut	6.260	13.8
2	Airlock door seal	6.396	14.1
1	Dock lock	11.204	24.7
1	Dock lock actuator	16.012	35.3
3	Dock port door seal	16.239	36.1
1	Viewport glass	18.960	41.8
1	Dock port door torsion assembly	22.589	49.8
1	Viewport glass	31.661	69.8
2	Viewport seal	31.752	70.0
3	Hydraulic lines/strut leak	32.206	71.0
1	Viewport glass airlock	34.927	77.0
1	Dock port door lock	45.360	100.0

Table 6-5

GPL MODULE LOGISTIC AND OPTIONS

Code	Description	Logistic Module Mass (kg)		
		1	2	3
07.00	Prime power			
	Batteries	725	725	--
10.00	Vehicle electronics			
	Film viewer	62	--	--
	Film digitizer	90	--	--
	Multichannel filter	9	--	--
	Processor	7	--	--
	Prevideo storage	45	--	--
	Predigital storage	18	--	--
	Work video storage	5	--	--
	Digital recorder (1)	18	--	--
	Portable CO display unit			
14.00	Crew life support and furnishing			
	Contingency H_2O (3)	154	154	154
	Contingency food (60 MD) (60 MD) (60-MD)	80	80	80
	Food storage (6)	16	16	16
17.00	Crew equipment			
	IVA support	4	--	--
	Medical provisions	25	20	--
	Fire extinguishers	11	--	--
	Tools	11	--	--

Table 6-5

GPL MODULE LOGISTIC AND OPTIONS (Continued)

Code	Description	Logistic Module Mass (kg)		
		1	2	3
18.00	GPL provisions			
	Film vault	--	--	2,268
	Microfilmer	--	--	23
	Light table	--	--	23
	Spectrophotometer	--	--	5
	Densitometer	--	--	9
	Battery charger	--	--	23
	High-energy counter calibrating equipment	--	--	23
	Cryogenic and fluid stowage	--	--	23
	High-pressure gas stowage	--	--	23
	Precision work fixture	--	--	23
	Microdensitometer	--	--	9
	Monochromator spectrometer	--	--	9
	Mod transfer measurement system	--	--	9
	Optical spectrum analyzer	--	--	9
	X-ray generator	--	--	9
	Precision work fixture	--	--	67
	Lower body negative pressure device	--	18	18
	Body mass measurement device	--	18	--
	Biomedical display and control unit	--	45	--
	Multiformat viewer editor	--	147	--
	Microfilm retrieval system	--	180	--
	Copy machine	--	45	--
	Spare	--	46	45
	Total mass	1,325 (2,922 lbm)	1,494 (3,294 lbm)	2,868 (6,323 lbm)

Table 6-6

LOGISTIC AND OPTIONS SUMMARY

	Logistic Module Mass (kg)		
Modules	1	2	3
Power module	1,972	1,117	173
Crew module	1,698	1,682	922
GPL module	1,325	1,494	2,868
Total mass	4,995 (11,012 lbm)	4,293 (9,466 lbm)	3,963 (8,738 lbm)

Section 7
INITIAL SPACE STATION CORE DETAIL WEIGHT SUBSTANTIATION

The Initial Space Station modules detail weights and the method of derivation are presented in this section, along with a brief description of each system. Also included within each functional-code writeup are the dependent design information for mass properties and the structural increments for secondary features. Schematic diagrams and drawings are included to facilitate coordination of weights to hardware.

Each functional code of the core module is followed by a detail summary of equipment, quantity, and weight. The weights are defined as a projection of hardware weights for the currently defined program and do not include an allowance for growth.

Several items warrant special attention. These include the logistic options which are not required during the unmanned assembly period. The weight presented here includes the initial launch weight plus the initial logistic options. Spares are logistic options also, and have been listed in this section as TBD. The actual values are covered with the other logistic options in Section 6. Mass properties of the buildup is covered in Section 2.

Terms which appear in the functional code tables and used in the text are defined to ensure a clear understanding of the material presented.

1. <u>"Design to" Weight</u>
   The Guidelines and Constraints document specifies a "design to" weight of 20, 000 lb for the shuttle launched Space Station modules. This design to weight has been treated as the maximum launch weight for each of the Space Station modules as defined at the completion of the Phase B study. As such, growth for improvement and

performance changes during the course of Phase C have not specifically been provided in the Phase B design to weight. However, each of the Space Station modules has a minimum launch weight of 10 percent or more below the design value.

2. Miscellaneous

Miscellaneous weights shown as a percentage of a basic calculated subsystem, assembly or component are adjustments to the weight for known weight increments. These increments are the effect of non-optimums, level of detail not defined at end of Phase B, and installation hardware that is not specifically defined.

Examples:

Pressure bottle; weld lands, bosses, etc., structure sidewall; access cutouts, local beefups, etc., plumbing; connectors, tie downs, rerouting, etc.

3. Contingency

Contingency weights shown as a percentage of a basic calculated weight are adjustments to the weight for unknown weight increments that are related to the confidence in the estimated weights or systems which historically grew during the development period. At the initiation of the Phase B study, contingency allowances were used to account for the fact that limited design information existed. Contingencies as high as 50 percent were used in certain areas—some were as low as 0 percent. No blanket contingency was assigned nor appropriate. As the detail design progressed and definition improved, these contingencies were progressively decreased so that at the completion of the Phase B, very few contingency allowances remain. Where applicable these allowances are shown in the appropriate subsystem weight breakdown (Section 7). Examples are:

Equipment Support Structure; 50%
Solar Array Blankets 5%
Quadrant Devices for Power System 15%
Wiring 10%

4. Phase C Subsystem Target Weights (Allowances)

The preliminary design, Phase B for the Modular Space Station has established an in-depth definition of the baseline systems for a "first of a kind" space vehicle. Considering the unique modular concept, the low cost of logistics resupply, but most importantly, the low initial cost, subsystem weight allocations for each subsystem should be made. These allocations should be established at initiation of Phase C and will require an in-depth study of potential weight increases or decreases that will occur as a result of any new advanced in the state-of-the-art. The completion of the Phase B baseline is felt to represent a well established subsystem definition based upon current knowledge. With the exception of the new developments, the present baseline weights are felt to be appropriate subsystem target weights for the initiation of Phase C.

The initial launch weight of each ISS module is summarized in Table 7-1.

7.1 STRUCTURE (FC 02.00)

The primary structure includes the pressurized compartment, the nominal unpressurized turret and tunnel, plus the manufacturing and material tolerances and finishes.

The unpressurized area includes the solar array tunnel supported off the forward end of the power module. Basically the tunnel is 245 in. in length with a 40-in. inside diameter. The membrane thickness is 0.050 in. with an equivalent skin thickness of 0.075 in. (2219-T87 aluminum). At the other end of the tunnel is the turret (Figure 7-1). The turret is machined in two sections from thick-walled forging of 2219-T87. Three identical harmonic drive/gimbal assemblies are also attached to the turret (Figure 7-2).

The pressurized compartment consists of the pressure sidewall which has an 160-in. inside diameter, stiffened with 24 equally spaced longitudinal ribs. The end flanges are integrally machined. Each of the three segments of 2219-T87 is welded longitudinally. The membrane is 0.060 in. with an equivalent skin thickness of 0.078 in. The conic transitions sections (skirts) have a membrane thickness of 0.060 in., with longitudinal stiffeners.

The hatch design is a common one used throughout the Space Station. All are capable of differential pressure (30 psi) in either direction and are of

Table 7-1

INITIAL SPACE STATION MODULAR SUBSYSTEM MASS SUMMARY

Code	Description	Power/Subsystems Module No. 1 Mass (lbm)	Power/Subsystems Module No. 1 Mass (kg)	Crew/Operations Module No. 1 Mass (lbm)	Crew/Operations Module No. 1 Mass (kg)	GPL Module Mass (lbm)	GPL Module Mass (kg)
02.00	Structure	3,308	1,501	3,480	1,579	3,783	1,716
03.00	Meteoroid/Thermal Protection	2,108	956	2,036	924	2,002	908
04.00	Docking Provisions	1,539	698	1,539	698	615	279
06.00	Propulsion	736	334	316	143	54	24
07.00	Prime Power	4,625	2,098	15	7	15	7
08.00	Power Conditioning and Distribution	673	305	287	130	288	131
10.00	Electronics	1,386	625	2,523	1,145	2,063	935
11.00	Wiring	580	263	794	360	1,032	468
12.00	Atmosphere and Thermal Control	831	377	1,287	583	1,259	5[illegible]
1? 00	Crew Life Support and Interiors	425	193	2,568	1,164	665	302
1? 00	Crew Equipment and Crew	0	0	0	0	0	0
18.00	GPL and Experiment Provisions or Cargo	--	--	--	--	3,163	1,435
21.00	Residuals	549	249	684	310	648	294
22.00	Reserves	223	101	--	--	--	--
23.00	Inflight Losses	530	240	--	--	--	--
	Minimum-Launch Total	17,513	7,943	15,529	7,043	15,587	7,070
	Discretionary Margin	2,487	1,129	4,471	2,029	4,413	2,002
	Target	20,000	9,072	20,000	9,072	20,000	9,072

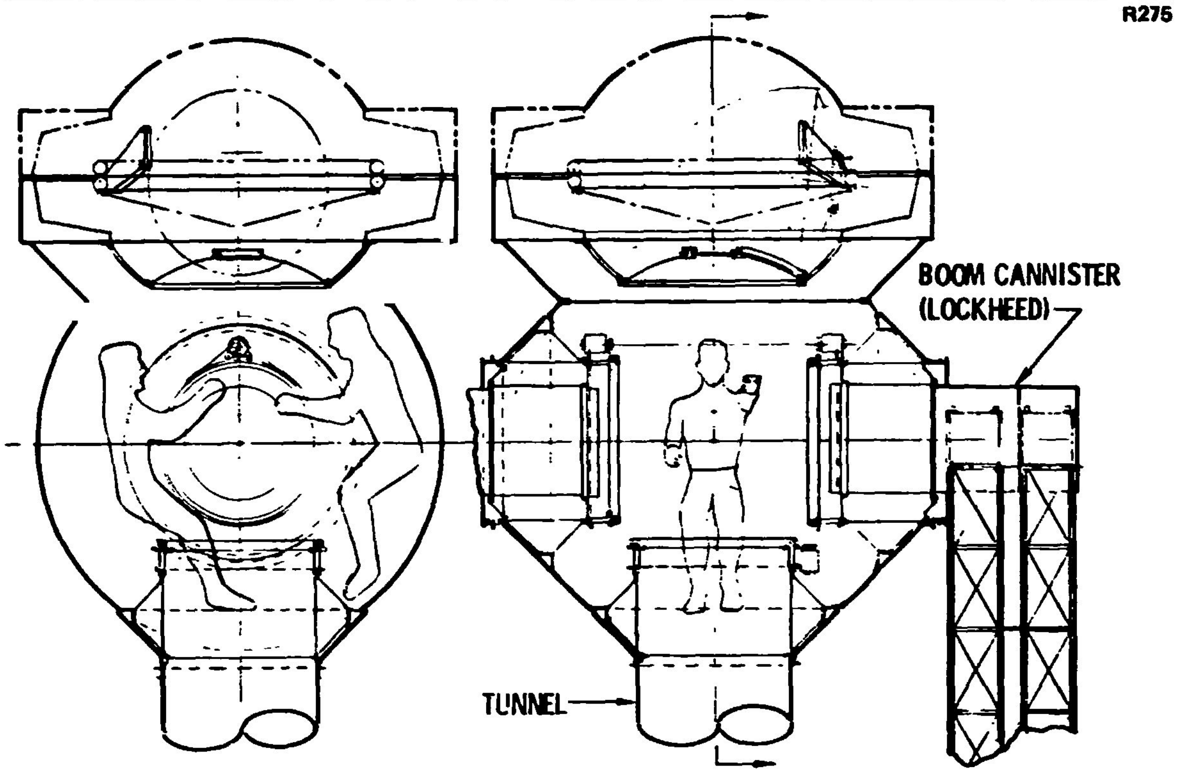


Figure 7–1. Turret Assembly

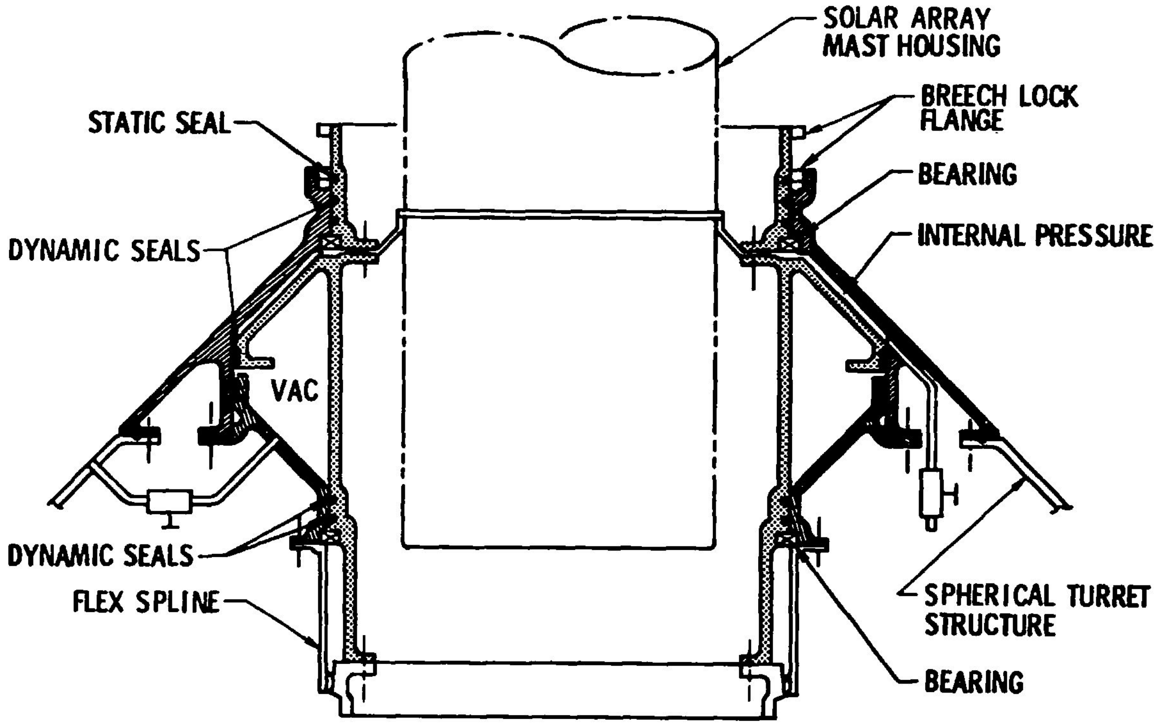


Figure 7–2. Drive and Gimbal Assembly

honeycomb design. The weights calculated were based on the preliminary design layout referenced on drawing 1B80098.' The skin facings are 0.016 in., the closing channels (A_{cs}) are 1.10 in.^{2}, the aluminum honeycomb core weighs (3.1 lb/ft^3) and is 0.5 in. thick with 0.08 lb/ft^2 per layer allowed for bonding material. A nonoptimum factor of 10 percent was added to these items to account for attachments and seals. When docked the domed hatches provide an intermodule IVA airlock. The hatches are of two sizes, 60 in. and 40 in.

The viewports incorporated throughout the Station permit general viewing, plus experiment and docking observation. In addition to the 6-in. viewports in all hatches there are a series of 12-in. viewports also located throughout the Station. These include three in the wardroom, one in each crew quarter, one at the primary and secondary D&C, one adjacent to the scientific airlocks (2). The weights reflect a double-pane of 0.56 fused silica.

The manufacturing tolerances all weights have been based on nominal dimensions, with the difference between nominal and actual manufactured weights being identified as tolerances. From statistical data based on the Thor, Saturn, and MOL Programs for both chemical and machined structures, a factor of approximately one-sixth of the total design tolerance has been established as manufacturing tolerance. This weight added to the nominal value would equal the manufactured weight. It is estimated that the average tolerance will be ±0.003 projected over an area in excess of 1000 ft^2/module.

The structural analysis and drawing are supplied in SE04, Section 4. The weights were derived using this data, and applying non-optimums for known items but not clearly defined. Contingency varying from 5 to 50 percent was applied to pertinent assemblies where applicable. Tables 7-2 through 7-4 summarizes the detail weights.

7.2 METEOROID AND THERMAL PROTECTION (FC 03.00)

Each Space Station Module is encapsulated by an external shroud which provides the radiator surface for the EC/LS system and the meteoroid and thermal protection.

Table 7-2

STRUCTURE DETAIL WEIGHTS FOR POWER MODULE

	Unit Weight	Total ISS Req	Logistic Options		Initial Launch	
			Quantity	Total Weight	Quantity	Total Weight
02.10 Unpressurized Struc						1,109
Turret	(514)	1			1	514
Shell	64					
Gimbal Rings (3)	330					
Cone	60					
Top Ring	13					
Misc (10%)	48					
Tunnel	(282)				1	282
Waffle	230					
Rings (2)	26					
Misc (10%)	26					
Conic	(253)	1			1	253
Shell	159					
Stiffeners (long)	12					
Rings (3)	60					
Access Panels (4)	10					
Misc 5%	12					
Interface Adapters	(60)					60

Table 7-2

STRUCTURE DETAIL WEIGHTS FOR POWER MODULE (Continued)

		Unit Weight	Total ISS Req	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight		
02.11	Pressurized Struc						2,154		
	Forward Dome	(120)				1		120	
	Membrane	114	1						
	Ring(1)								
	Misc 5%	6							
	Skirt	(180)	5			1		180	
	Shell	96.7	--						
	Stiffeners (24)	5.7	--						
	Rings	59.7	--						
	Access Panels (4)	9.6	--						
	Misc 5%	8.6	--						
	Sidewall					1		1,230	
	Waffle	$\bar{t} = 0.078$	--						729
	D. P. Beefup	38.1	--						114
	Cir Rings	39.3	--						79
	Dome Ring	39.3	--						39
	Interface Beefup	24.0	--						24
	Cir Stiff (DP)	--	--						111
	Long Joints	--							75
	Misc 5%	--	--						59
	Equipt Sup. Struc	--	--	--	--			253	
	Structure								169
	Contingency								84
	Hatches							378	
	DP Hatches	54	12			5			270
	Misc Hatch	36	3			2			108
	GPL Floor Hatch	36	1			--			--

NOTES:
(1) Carried in sidewall weight.

Table 7-2

STRUCTURE DETAIL WEIGHTS FOR POWER MODULE (Continued)

	Unit Weight	Total ISS Req	Logistic Options		Initial Launch			
			Quantity	Total Weight	Quantity	Total Weight		
Viewport							42	
General (12 in.)	23	12			--			--
Hatches (6 in.)	6	15			7			42
Optic (12 in.)	26	1			--			--
Airlocks(2)	---	--			--		--	--
GPL Bulkhead	(565)	1	--	--	--		--	
Core	217							
Bond	22							
Skins(2)	313							
Misc	13							
02.15 Finish, Seals, Spares						38		
Finish	0.0046 lb/ft^2	--	--	--			23	
Seal (FC 02.10/11)	---	--	--	--			--	
Spares	---	--		TBD			--	
Tolerance	+0.003	--	--	--			15	
Structure						3,308 (1,501 Kg)		

NOTES:
(2) Functional coded to GPL (18.00). (3) Carried in component weights.

Table 7-3

STRUCTURE DETAIL WEIGHTS FOR CREW MODULE

		Unit Weight	Total ISS Req	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight
02.10	Unpressurized Struc					(60)	
	Turret	(514)	1				--
	Shell	64					
	Gimbal Rings (3)	330					
	Cone	60					
	Top Ring	13					
	Misc 5%	48					
	Tunnel	(282)					--
	Waffle	230					
	Rings (2)	26					
	Misc (10%)	26					
	Conic	(253)	1				--
	Shell	159					
	Stiffeners (long)	12					
	Rings (3)	60					
	Access Panels (4)	10					
	Misc 5%	12					
	Interface Adapters	(60)					60
02.11	Pressurized Struc					3, 382	
	Forward Dome	(120)					--
	Membrane	114	1				
	Ring (1)	6					
	Misc 5%						
	Skirt	(180)	5			2	360
	Shell	96.7	--				
	Stiffeners (24)	5.7	--				
	Rings	59.7	--				
	Access Panels (4)	9.6	--				
	Misc 5%	8.6	--				

(1) Carried in sidewall weight.

Table 7-3

STRUCTURE DETAIL WEIGHTS FOR CREW MODULE (Continued)

	Unit Weight	Total ISS Req	Logistics Options Quantity	Logistics Options Total Weight	Total Weight Quantity	Total Weight	
Sidewall						2,065	
Waffle	$\bar{t} = 0.078$	--					1,502
D. P. Beefup	38.1	--					114
Cir Rings	39.3	--					79
Dome Ring	39.3	--					--
Interface Beefup	24.0	--					24
Cir Stiff (DP)	--	--					111
Long Joints	--	--					137
Misc 5%	--	--					98
Equipt. Sup. Struc	--	--				450	
Structure							300
Contingency							150
Hatches						270	
DP Hatches	54	12			5		270
Misc Hatch	36	3			--		--
GPL Floor Hatch	36	1			--		--
Viewport						237	
General (12 in.)	23	12			9		207
Hatches (6 in.)	6	15			5		30
Optic (12 in.)	26	1			--		--

Table 7-3

STRUCTURE DETAIL WEIGHTS FOR CREW MODULE (Continued)

	Unit Weight	Total ISS Req	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight
Airlocks (2)	--	--	--	--	--	--
GPL Bulkhead	(565)	1				--
Core	217					
Bond	22					
Skins (2)	313					
Misc	13					
02.15 Finish, Seals, Spares						38
Finish	0.0046 lb/ft²	--				23
Seal (FC 02.10/11)	--	--				--
Spares	--	--				--
Tolerance	±0.003	--				15
02.19 Cont (3)			--	--		--
02.00 Structure						3,480 (1,579 Kg)

NOTES:
(2) Functional coded to GPL (18.00)
(3) Carried in component weights

Table 7-4

STRUCTURE DETAIL WEIGHTS FOR GPL MODULE

	Unit Weight	Total ISS Req	Logistic Options		Initial Launch	
			Quan-tity	Total Weight	Quan-tity	Total Weight
02.10 Unpressurized Struc						60
Turret	(490)	1				--
Shell	64					
Gimbal Rings (3)	330					
Cone	60					
Top Ring	13					
Misc 5%	24					
Tunnel	(282)					--
Waffle	230					
Rings (2)	26					
Misc (10%)	26					
Conic	(253)					--
Shell	159					
Stiffeners (long)	12					
Rings (3)	60					
Access Panels (4)	10					
Misc 5%	12					
Interface Adapters	(60)					60

Table 7-4

STRUCTURE DETAIL WEIGHTS FOR GPL MODULE (Continued)

	Unit Weight	Total ISS Req	Logistic Options Quan-tity	Logistic Options Total Weight	Initial Launch Quan-tity	Initial Launch Total Weight		
02. 11 Pressurized Struc						3, 685		
Forward Dome	(120)						--	
Membrane	114							
Ring (1)	6							
Misc 5%								
Skirt	(180)				2		360	
Shell	96. 7							
Stiffeners (24)	5. 7							
Rings	59. 7							
Access Panels (4)	9. 6							
Misc 5%	8. 6							
Sidewall							2, 053	
Waffle	$\bar{t}$ = 0. 078							1, 677
D. P. Beefup	38. 1							--
Cir Rings	39. 3							79
Dome Ring	39. 3							39
Interface Beefup	24. 0							24
Cir Stiff (DP)	--							--
Long Joints	--							136
Misc 5%	--							98
Equipt Sup. Struc	--	--	--	--			450	
Structure								300
Contingency								150
Hatches							144	
DP Hatches	54	12				2		103
Misc Hatch	36	3				--		--
GPL Floor Hatch	36	1				1		36

(1) Carried in sidewall weight

Table 7-4

STRUCTURE DETAIL WEIGHTS FOR GPL MODULE (Continued)

	Unit Weight	Total ISS Req	Logistic Options Quan-tity	Logistic Options Total Weight	Initial Launch Quan-tity	Initial Launch Total Weight		
Viewport							113	
General (12 in.)	23	12			3			69
Hatches (6 in.)	6	15			3			18
Optic (12 in.)	26	1			1			26
Airlocks[2]	--	--	--	--	--			
GPL Bulkhead	(656)	--			1		565	
Core	217							217
Bond	22							22
Skins (2)	313							313
Misc	13							13
02.15 Finish, Seals, Spares						38		
Finish							23	
Seal (FC 02.01/11)							--	
Spares							--	
Tolerance							15	
02.19 Cont[3]						--		
Structure						3,783 (1,716 Kg)		

NOTES:
(2) Functional coded to GPL (18.00). (3) Carried in component weights.

The ECS Radiator/Meteoroid Shroud/Thermal Insulation Assembly for each of the three Space Station modules has an active and a redundant radiator system, either of which is capable of accommodating the nominal module heat load. The outer surface is formed from extruded 6061-T6 with a skin thickness of 0.016 in. A second bumper of 7075-T6 with a skin thickness of 0.010 in. protects the 50 sheets of high-performance insulation.

The extruded radiator tubes (Figure 7-3) are longitudinally oriented, and are an integral part of the radiator/meteoroid bumper to minimize the temperature drop between the radiator fluid (Freon 21) and the radiating surface. The manifolding is arranged so that each fluid pass travels half way around the vehicle circumference so that the outlet is located 180 degrees away from the inlet. The number of tubes in parallel is selected so that with a tube diameter of 0.483 cm (0.190 in.), which is the smallest diameter it is practical to extrude, the flow rate gives a Reynolds number in excess of 10,000 to maximize the heat rejection capacity. The serpentine tube arrangement with the opportunity (within 90 degrees) to select the inlet location, allows the fluid to flow in the direction of decreasing heat sink.

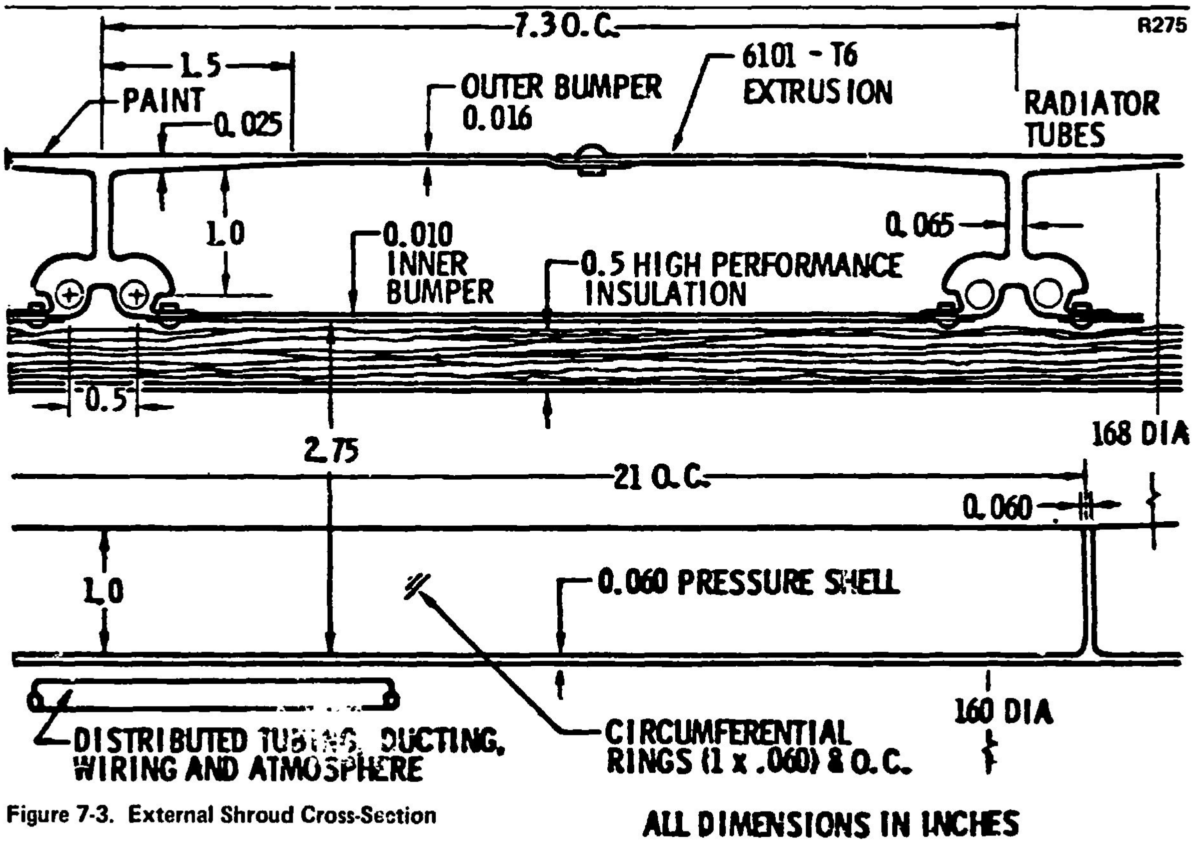


Figure 7-3. External Shroud Cross-Section

To provide a 0.99 reliability for the thermal control system both the active and the redundant radiators have a 0.90 probability of sustaining no puncture or spalling of a tube in a 10-year mission. So that a common extrusion may be used for all the modules the shielding is sized for the GPL which has the greatest length of tubing, and thus the greatest exposed area. The GPL has 72 tubes in each radiator (5 degrees spacing) and the tubes run the full length of tubing for one radiator is 830 meters (2,720 ft).

The weights were estimated, using the shroud layout (1B90022). The skins/ frames include a 5 percent allowance for fittings and access provisions plus a 3 percent nonoptimum factor for routing variations and access provisions.

The manifolds are 0.50-in.-diameter aluminum tubing and have a wall thickness of 0.065 in. The four ECS radiator segments has 2,100 in. of manifold tubing, and an additional 10 percent was added for supports and nonoptimum routing.

Seven mils of Z-93 thermal coating is also applied over the total radiator to decrease the absorbtivity and the emissivity.

The insulation protection is used to maintain the pressizable closure surface temperature above the atmosphere's dew point. The protection is basically a two-blanket concept in which each blanket contains 25 aluminized mylar sheets separated by dacron-net spacers. The outer dacron net is impregnated with resin to strengthen it. The blankets cover the tunnel turret, conical section, sidewall, skirts, and docking port. The unit weight was obtained from current blanket weight of actual designs. An additional 5 percent was added for locally attaching the blanket to the structure.

The meteoroid protection over the turret, docking ports, tunnel, and skirts is composed of a corrugated 0.012 sheet ($\bar{t}$ = 0.016) and an inner bumper of beaded 0.010. The weight includes a 25 percent additional allowance for fitting and related provisions.

Solar Collectors (150 ft^2) are included on the astromasts for added heat rejection capability. These weights were estimated by using the same unit value as the baseline radiator which is considered conservative.

Table 7-5 summarizes the design parameters with the detailed weights summarized in Tables 7-6 through 7-8. The freon in the radiator is included in function code Residuals (FC 21, 0).

7.3 DOCKING PROVISIONS (FC 04.00)

The docking is accomplished by a deployable and retractable square docking frame mounted on a system of eight shock absorbers/actuators which absorb the docking energy. The docking frame is a square structure fabricated from aluminum tubing. The tubing measures approximately 3 in. OD and has a cross-sectional area of 0.78 in.^{2}. The eight actuators, which are fabricated from aluminum and are approximately 50 in. long in the extended position have an outside diameter of approximately 1.6 in. The weight of the two motors used to extend and retract the latching ring was estimated, using a semi-empirical equation. The pressure-seal ring is a short cylindrical section, which houses the latching ring and two inflatable pressure seals. Docking alignment is aided by a set of guide arms at 90 degrees. Once the vehicles are mated, the docking frame is retracted, the pressure seals are inflated, and the latches are deployed to lock the vehicles together. The 12 latches are designed so that either interface set can carry the internal pressure load (30 psi). This arrangement provides complete redundancy. The latches are activated in unison by an electrical motor and torque tube drive. Also included in each interface is an inflatable seal backed by an aluminum filler which provides a seat for the mating seals. Either or both seals can be pressurized to prevent leakage. The mechanism is designed to accept a centerline miss distance of ± 1.0 feet, and a pitch, roll, and yaw misalignment of ± 5 degrees. Figure 7-4 illustrates the system mechanism.

The weights which are detailed in Table 7-9 and 7-10 were derived from structural analysis with a 10 percent contingency applied to all values.

7.4 PROPULSION (FC 06.00)

The Modular Space Station Propulsion Subsystem is a combination Monopropellant (N_2H_4) High-Thrust (111 N/Thrustor, 25 LBF/Thrustor) System and a Biowaste (CO_2) Resistojet Low-Thrust (0.111 N/Thrustor, 0.025 LBF/Thrustor) System. The Low Thrust System performs orbit keeping and CMG desaturation and the High Thrust System provides impulse for attitude

Table 7-5

METEOROID AND THERMAL PROTECTION DESIGN PARAMETERS

Environmental Control Shroud	
Outer Skin/Radiator Tube	0.016 in. (6061-T6)
Inner Skin	0.010 in. (7075-T6)
Manifold	Redundant (100%) (0.50 in. dia)
Radiator Tubes/Diameter	Redundant (100%) (72) 0.19 in. ID
Thermal Coating	Z-93 (7 mil)
Reliability (System)	0.99
Coolant	Freon 21 (Density 86.7 lb/ft^3)
Design Heat Rejection Capability (Power/Crew/GPL)	(20, 213), (32, 120), (43, 456) BTU/hr (Average)
Non-Optimum — Manifold	10%
Non-Optimum — Skin/Radiator Tube	5%
Insulation	
Material	50 Sheet (DAM) Alumized Mi
Non-Optimum	5%
Metoroid Shield (Docking Ports, Skirts, Tunnel, and Turret)	
Outer Skin	0.012 Corrugated ($\bar{t}$ = 0.016 in.)
Inner Skin	0.012 Beaded
Material	7075-T6
Non-Optimum	25%

Table 7-6

METEOROID AND THERMAL PROTECTION DETAIL WEIGHTS FOR POWER MODULE

	Unit Weight	Total ISS Req	Logistic Options: Quan-tity	Logistic Options: Total Weight	Power Module Initial Launch: Quan-tity	Power Module Initial Launch: Total Weight		
03. 01 Active Thermal Control						1, 156		
Solar Collectors & Manifold							295	
Radiator							771	
Outer Skin/Tubes								574
Inner Skin								115
Manifold								43
Fittings								39
Spares	--	--		TBD				
Misc 10%	--	--	--	--			90	
03. 02 Passive Thermal Protection						490		
Insulation (0. 190 lb/ft²)							365	
Sidewall	--	--			--			144
Conic	38. 0	1			1			38
Skirt	30. 4	5			1			30
Tunnel	43. 7	1			1			44
Turret	52. 6	1			1			53
Hatches	11. 2	12			5			56
Thermal Coating (0. 06 lb/ft²)							125	
Sidewall	--	--			--			46
Conic	12. 0	1			1			12
Skirts	9. 6	5			1			10
Tunnel	13. 8	1			1			14
Turret	16. 6	1			1			17
Hatch Covers	3. 5	10			5			17
Solar Collector								9
03. 04 Meteoroid Protection						462		
Sidewall	--	--			--		--	
Conic	--	1			--		--	
Skirt	77	5			1		77	
Tunnel	111	1			1		111	
Turret	134	1			1		134	
Hatch Covers	28	10			5		140	
03. 00 Meteoroid and Thermal Protection					2, 108 (956 Kg)			

Table 7-7

METEOROID AND THERMAL PROTECTION DETAILS WEIGHTS FOR CREW MODULE

	Unit Weight	Total ISS Req	Logistic Options		Crew Module Initial Launch			
			Quan-tity	Total Weight	Quan-tity	Total Weight		
03.01 Active Thermal Control						1,253		
Radiator							1,139	
Outer Skin/Tubes								854
Inner Skin								184
Manifold								43
Fittings								58
Spares	--	--		TBD			--	
Misc 10%	--	--	--	--			114	
03.02 Passive Thermal Protection						517		
Insulation (0.190 lb/ft^2)							396	
Sidewall	--	--						279
Conic	38.0	1			--			--
Skirt	30.4	5			2			61
Tunnel	43.7	1			--			--
Turret	52.6	1			--			--
Hatches	11.2	12			5			56
Thermal Coating (0.06 lb/ft^2)							121	
Sidewall	--	--			--			88
Conic	12.0	1						--
Skirts	9.6	5			2			19
Tunnel	13.8	1			--			--
Turret	16.6	1			--			--
Hatch Covers	3.5	10			4			14
03.04 Meteoroid Protection						266		
Sidewall	--	--			--		--	
Conic	--	1			--		--	
Skirt	77	5			2		154	
Tunnel	111	1			--		--	
Turret	134	1			--		--	
Hatch Covers	28	10			4		112	
0.300 Meteoroid and Thermal Protection						2,036 (924 Kg)		

Table 7-8

METEOROID AND THERMAL PROTECTION DETAIL WEIGHTS FOR GPL MODULE

		Unit Weight	Total ISS Req	Logistic Options: Quantity	Logistic Options: Total Weight	Initial Launch: Quantity	Initial Launch: Total Weight		
03.01	Active Thermal Control						1,324		
	Radiator							1,204	
	Outer Skin/Tubes								895
	Inner Skin								209
	Manifold								43
	Fittings								57
	Spares	-	-		TBD			-	
	Misc 10%	-	-	-	-			120	
03.02	Passive Thermal Protection						496		
	Insulation (0.190 lb/ft²)							374	
	Sidewall	-	-						313
	Conic	38.0	1			-			-
	Skirt	30.4	5			2			61
	Tunnel	43.7	1			-			-
	Turret	52.6	1			-			-
	Hatches	11.2	12			-			-
	Thermal Coating (0.06 lb/ft²)							122	
	Sidewall	-	-						9[illegible]
	Conic	12.0	1			-			-
	Skirts	9.6	5			2			19
	Tunnel	13.8	1			-			-
	Turret	16.6	1			-			-
	Hatch Covers	3.5	10			1			4
03.04	Meteoroid Protection						182		
	Sidewall	-	-			-		-	
	Conic	-	1			-		-	
	Skirt	77	5			2		154	
	Tunnel	111	1			-		-	
	Turret	134	1			-		-	
	Hatch Covers	28	10			1		28	
0.300	Meteoroid and Thermal Protection						2,002 (908 Kg)		

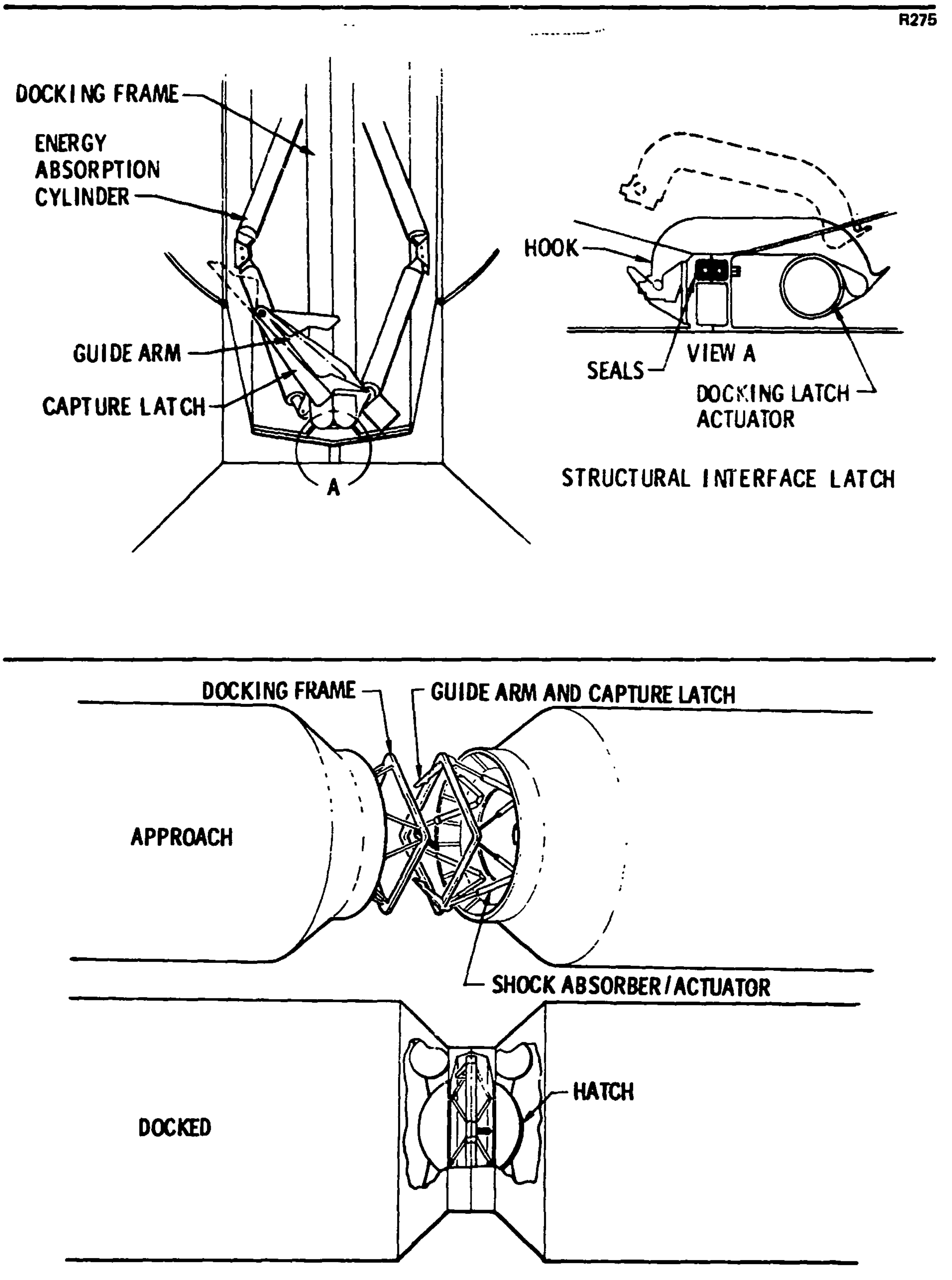


Figure 7–4. Docking Mechanism and Interface Latches

Table 7-9

DOCKING PROVISIONS DETAIL WEIGHT SUMMARY FOR POWER AND CREW MODULE

				Crew and Power Module			
				Logistic Options		Initial Launch	
		Unit Weight	Total ISS Req	Quantity	Total Weight	Quantity	Total Weight
04.05	Docking Structure					1,539	
	Ring Assembly	(322)	12	--	--	5	161
	Tubes (4)	19.2					
	End Fittings (4)	13.0					
	Shock Absorber/ Actuator (8)	(41.6)	12	--	--	5	208
	Guide Arm/Captive Latch (2)	(4.0)	12	--	--	5	20
	Interface Latches and Activation Subsystem	(38.0)	12	--	--	5	190
	Latches (12) (25%)	16.7					
	Torque Tube (21)	5.8					
	Splines (24)	10.0					
	Drive Motor	2.0					
	Misc. (10%)	3.5					
	Seal and Inflation Sys	(4)	12	--	--	5	20
	Seal	1					
	Lines and Valves	2					
	Misc. (20%)	1					
	Hydraulic Assembly	(15.9)	12	--	--	5	80
	Accumulator (25%)	4.2					
	Valves (9)	4.5					
	Lines/Etc.	0.6					
	Piston (50%)	4.1					
	Misc. (10%)	2.5					
	Structure Closure	(172)	12			5	860
	Interface Frame	26					
	Gussets 1	79					
	CLY Shell	32					
	Pressure Bulkhead	35					
04.19	*Contingency	--	--	--	--	--	--
04.00	Docking Provisions					1,539 (698 Kg)	

*Included with each item.

Table 7-10

DOCKING PROVISIONS DETAIL WEIGHT SUMMARY FOR GPL MODULE

				CPC Module			
				Logistic Options		Initial Launch	
		Weight	Total ISS Req	Quantity	Total Weight	Quantity	Total Weight
04.05	Docking Structure						615
	Ring Assembly	(32.2)	12	--	--	2	64
	Tubes (4)	19.2					
	End Fittings (4)	13.0					
	Shock Absorber/ Actuator (8)	(41.6)		--	--	2	83
	Guide Arm/Captive Latch (2)	(4.0)		--	--	2	8
	Interface Latches and Activation Subsystem	(38.0)	12	--	--	2	76
	Latches (12)	16.7					
	Torque Tube (21)	5.8					
	Splines (24)	10.0					
	Drive Motor	2.0					
	Misc. (20%)	3.5					
	Seal and Inflation Sys	(4)	12	--	--	2	8
	Seal	1					
	Lines and Valves	2					
	Misc. (20%)	1					
	Hydraulic Assembly	(15.9)	12	--	--	2	32
	Accumulator	4.2					
	Valves (9)	4.5					
	Lines/Etc.	0.6					
	Piston	4.1					
	Misc. (10%)	2.5					
	Structure	(172)	12	--	--	2	344
	Interface Frame	26					
	Gussets	79					
	CLY Shell	32					
	Pressure Bulkhead	35					
04.19	*Contingency	--	--	--	--	--	--
04.00	Docking Provisions						615 (279 Kg)

*Included within each item.

maneuvers and the correction of docking/de-docking disturbances when the Orbiter is not attached. Figure 7-5 illustrates the propulsion installation.

The propulsion elements, excepting thrustors, are located in an unpressurized, but pressurizable bay in the forward conic section of the Power Module. This provides isolation in the event system failures cause leakage of propellant or pressurant. Maintenance may be performed in either an IVA or shirtsleeve mode depending upon the nature of the maintenance, i. e., most maintenance will not involve opening a propellant system and will be shirtsleeve.

7.4.1 High-Thrust Subsystem

The High-Thrust Propulsion (N_2H_4) is stored in positive expulsion metal bellows tankage and expelled with regulated GN_2. Of the four propellant tanks required, only one at a time is pressurized and in use. The propellant is routed through dual feed lines to the eight thrustor modules four of which are located on the forward end of the Power Module and four on the aft end of the Crew Module. The High-Thrust System usage will be very infrequent. Tankage is sized for the initial 90 days without CMG's plus a 30-day reserve (753 lbm) and a 5 percent residual allowance. Design parameters of the High Thrust Subsystem are listed in Table 7-11, with a schematic of the subsystem in Figure 7-6. The detail weights are included in Table 7-12 (Power Module), 7-13 (Crew Module) and 7-14 (GPL Module).

7.4.2 Low-Thrust Subsystem

The Low-Thrust Subsystem receives waste CO_2 from the EC/LS Subsystem and routes the CO_2 to the Power Module where it is compressed and stored in titanium spheres as a gas. The CO_2 is regulated to approximately three atmospheres for distribution to the thrustors where it is electrically heated and expelled.

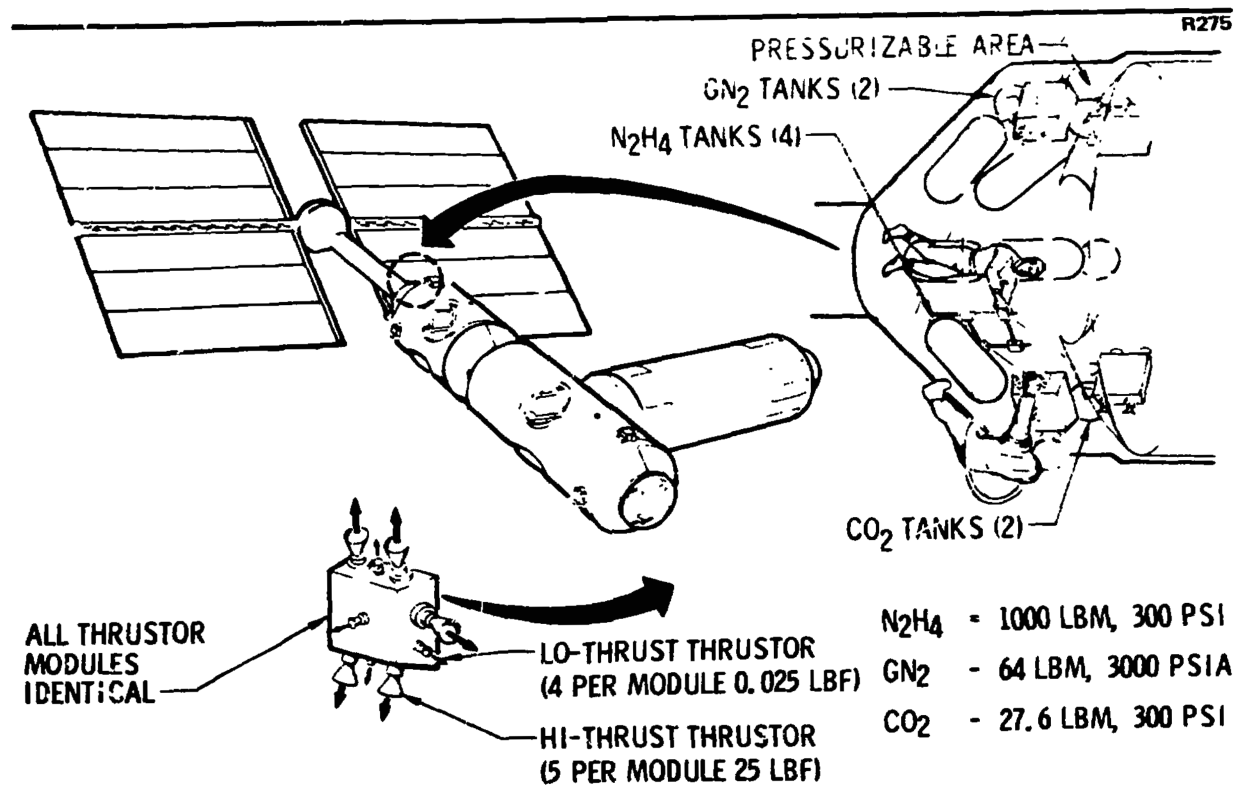


Figure 7-5. Propulsion Installation

Table 7-11

HIGH THRUST PROPULSION SUBSYSTEM DESIGN PARAMETERS

Propulsion	
Propellant	Monopropellant (N_2H_4) (30-Day Reserve) Density 64.0 lb/ft^3
Capacity	753 lbm
Operation Pressure	300 psia
Design Pressure	600 psia
Stowage Tanks	
Length	46 in.
Diameter	18 in.
Material	Titanium Shell; Stainless Steel Bellows
Quantity	4
Non-optimum	20% Shell/30% Bellows
Pressurization	
Pressurant	GN_2 (50% Reserve)
Capacity	46 lbm
Storage Pressure	(3000 → 500 psia)
Design Pressure	6000 psia
Regulated Pressure	300 psia
Stowage Tanks	
Diameter	16 in.
Material	Titanium
Quantity	2
Non-optimum	10%
Thrustors	
Thrust Level	25 lbm/Thrustor
Expansion Ratio	50:1
ISP (Pulsing)	180 sec
ISP (Steady State)	230 sec
Catalyst	Shell 405
Quantity	20/Module (100% Redundant)
Plumbing	
Propellant Lines	3/8 → 3/4 Aluminum (Min Gage 0.028 in.)
Pressurization Lines	1/4 in. diameter Stainless Steel (Min Gage 0.020 in.)
Non-Optimum	None
Quantity	100% Redundant

Note: Initial orbital altitude of 270 nmi permits the deletion of orbit keeping propellant for the first 160 days. Solar array are also feathered to reduce drag during unmanned buildup period (0 to 90 days).

Table 7-12

PROPULSION DETAIL WEIGHTS FOR POWER MODULE

	Unit Weight	Total ISS Req	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight		
6.01 Thrustor Assembly						208		
High Thrust							108	
Thrustors	5	40			20			100
Isolation Valve	1	8			4			4
Filter Assembly	1	8			4			4
Low Thrustor							52	
Thrustors	2	32			16			32
Isolation Valve	1	8			4			4
Transformer	1	32			16			16
Fairing	12	8			4			48
6.07 Fuel Container						142		
High Thrust							118	
Shell Assembly (20%)	16.1	4			4			64
Bellow Assembly (30%)	10.6	4			4			42
Burst/Relief Valve	3	2			2			6
Isolation Valve	1	2			2			2
Press Switch	1	4			4			4
Low Thrust							24	
Storage	18	2	2	36	-			-
Relief Valve	2	2			2			4
Pump Assembly	8	2			2			16
Isolation Valve	2	2			2			4
Relief Valve	2	2	2	4	-			-

Table 7-12

PROPULSION DETAIL WEIGHTS FOR POWER MODULE (Continued)

	Unit Weight	Total ISS Ref	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight		
6.09 Pressurization Assembly						95		
Pressurization Bottles							55	
Shell 10%	22.8	2			2			45
Burst/Relief Valve	3	2			2			6
Isolation Valve	2	2			2			4
Lines		-					22	
Pressurization and Purge Control Assembly							18	
Inlet Filter	1	2			2			2
Solenoid	2	4			4			8
Regulator	2	2			2			4
Press Switch	1	4			4			4
6.10 Fuel Distribution and Controls						93		
High Thrust							21	
Lines	-	-						13
Valves	2	4			4			8
Low Thrust							72	
Inverter	6	2			2			12
Controls	16	2			2			32
Valves	2	2			2			4
Filter	1	2			2			2
Lines	-	-						22

Table 7-12

PROPULSION DETAIL WEIGHTS FOR POWER MODULE (Continued)

	Unit Weight	Total ISS Req	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight		
6.14 Umbilicals						55		
Press Resupply							30	
Fill Umbilical	1	12			5			5
Fill Filter	1	12			5			5
Valves	1	24			10			10
Dispensing Umbilical	2	12			5			10
Propellant Resupply							25	
Fill Umbilica.	1	12			5			5
Fill Filter	1	12			5			5
Valves	1	24			10			10
Dispensing Umbilical	1	12			5			5
6.12 Support Structure						143		
Propellant							135	
Pressurization							4	
Misc							4	
6.21 Spares				TBD	-	-	-	-
6.00 Propulsion				40		736 (334 Kg)		

Table 7-13

PROPULSION DETAIL WEIGHT FOR CREW MODULE

	Unit Weight	Total ISS Req	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight
6.01 Thrustor Assembly						208
High Thrust						108
Thrustors	5	40			20	100
Isolation Valve	1	8			4	4
Filter Assembly	1	8			4	4
Low Thrustor						52
Thrustors	2	32			16	32
Isolation Valve	1	8			4	4
Transformer	1	32			16	16
Fairing	12	8			4	48
6.07 Fuel Container						-
High Thrust						
Shell Assembly	16.1	4				
Bellow Assembly	10.6	4				
Burst/Relief Valve	3	2				
Isolation Valve	1	2				
Press. Switch	1	4				
Low Thrust						
Storage	18	2				
Relief Valve	2	2				
Pump Assembly	8	2				
Isolation Valve	2	2				
Relief Valve	2	2				

Table 7-13

PROPULSION DETAIL WEIGHT FOR CREW MODULE (Continued)

	Unit Weight	Total ISS Req	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight		
6.09 Pressurization Assembly						18		
Pressurization Bottles								
Shell	22.8	2					-	
Burst/Relief Valve	3	2						-
Isolation Valve	2	2						-
Lines		-					18	
Pressurization and Purge Control Assembly							-	
Inlet Filter	1	2						
Solenoid	2	4						
Regulator	2	2						
Press. Switch	1	4						
6.10 Fuel Distribution and Controls						31		
High Thrust							13	
Lines	-	-						13
Valves								-
Low Thrust							18	
Inverter	6	2						-
Controls	16	2						-
Valves	2	2						-
Filter	1	2						-
Lines	-	-						18

Table 7-13

PROPULSION DETAIL WEIGHT FOR CREW MODULE (Continued)

	Unit Weight	Total ISS Req	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight		
6.14 Umbilicals						55		
Press. Resupply							30	
Fill Umbilical	1	12			5			5
Fill Filter	1	12			5			5
Valves	1	24			10			10
Dispensing Umbilical	2	12			5			10
Propellant Resupply							25	
Fill Umbilical	1	12			5			5
Fill Filter	1	12			5			5
Valves	1	24			10			10
Dispensing Umbilical	1	12			5			5
6.12 Support Structure						4		
Propellant							-	
Pressurization							-	
Misc.							4	
6.21 Spares	-	-	-	TBD	-	-		
6.00 Propulsion						316 (143 Kg)		

Table 7-14

PROPULSION DETAIL WEIGHTS FOR THE GPL MODULE

	Unit Weight	Total ISS Req	Logistic Options		Initial Launch	
			Quantity	Total Weight	Quantity	Total Weight
6.01 Thrustor Assembly						
High Thrust						
Thrustors	5	40				
Isolation Valve	1	8				
Filter Assembly	1	8				
Low Thrustor						
Thrustors	2	32				
Isolation Valve	1	8				
Transformer	1	32				
6.07 Fuel Container						
High Thrust						
Shell Assembly	16.1	4				
Bellow Assembly	10.6	4				
Burst/Relief Valve	3	2				
Isolation Valve	1	2				
Press. Switch	1	4				
Low Thrust						
Storage	18	2				
Relief Valve	2	2				
Pump Assembly	8	2				
Isolation Valve	2	2				
Relief Valve	2	2				

Table 7-14

PROPULSION DETAIL WEIGHTS FOR THE GPL MODULE (Continued)

	Unit Weight	Total ISS Req	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight		
6.09 Pressurization Assembly						12		
Pressurization Bottles							-	
Shell	22.8	2						-
Burst/Relief Valve	3	2						-
Isolation Valve	2	2						-
Lines		-					12	
Pressurization and Purge Control Assembly							-	
Inlet Filter	1	2						-
Solenoid	2	4						-
Regulator	2	2						-
Press. Switch	1	4						-
6.10 Fuel Distribution and Controls						18		
High Thrust							6	
Lines	-	-						6
Valves								-
Low Thrust							12	
Inverter	6	2						-
Controls	16	2						-
Valves	2	2						-
Filter	1	2						-
Lines	-	-						12

Table 7-14

PROPULSION DETAIL WEIGHTS FOR THE GPL MODULE (Continued)

	Unit Weight	Total ISS Req	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight		
6.14 Umbilicals						22		
Press. Resupply							12	
Fill Umbilical	1	12			2			2
Fill Filter	1	12			2			2
Valves	1	24			4			4
Dispensing Umbilical	2	12			2			4
Propellant Resupply							10	
Fill Umbilical	1	12			2			2
Fill Filter	1	12			2			2
Valves	1	24			4			4
Dispensing Umbilical	1	12			2			2
6.12 Support Structure						2		
Propellant							-	
Pressurization							-	
Misc.							2	
6.21 Spares				TBD				
6.00 Propulsion						54 (24 Kg)		

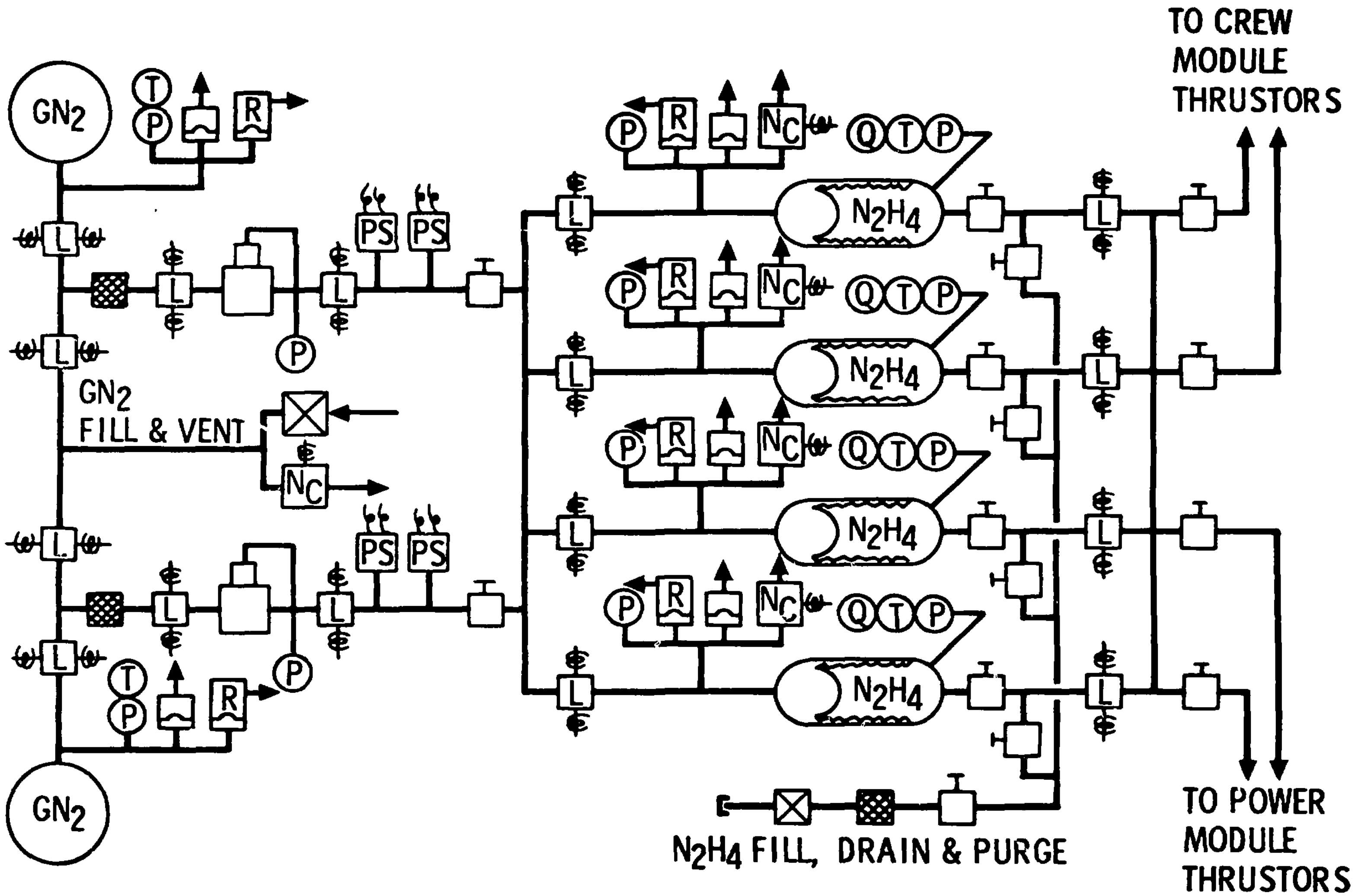


Figure 7-6. High Thrust Propulsion Reaction Control Subsystem Schematic

The CO_2 compression is a nearly continuous function subject to some changes in supply pressure and quantity. The consumption will also be at a high-duty cycle. The propellant (CO_2) requirements for orbit keeping, combined with CMG desaturation, if desired, are approximately equal to the EC/LS output during maximum solar density years. During low solar density years, most of the CO_2 will be expelled non-propulsively through opposing resistojets. The low thrust tankage is supplied via the logistic options plan. The design parameters are listed in Table 7-15 with the subsystem schematic illustrated in Figure 7-7. The detail weights are contained in Table 7-13 through 7-15.

7.5 PRIME POWER (FC 07.00)

The electrical power system is sized to supply both the Station and experiment program requirements as illustrated in Figure 7-8. It consists of 12 independent colar array panels equally divided between two wings and backup battery assemblies. The load analysis by subsystem are noted in Table 7-16 and was used to size the power system.

The Solar Array deployment and orientation assembly provides: (1) initial array deployment from the stowed position around the power tunnel, (2) individual panel retraction for EVA replacement, (3) group panel retraction for stowage and return of the Power/Subsystems Module, and (4) two-axis gimbal orientation on a continuous basis to ensure maximum solar energy collection for all Station flight attitudes. The solar panels are "feathered" for minimum drag during eclipse periods, and are recycled prior to reentering the sunlight to unwind the trailing cables which transfer power across the gimballed interfaces. The solar arrays are arranged to provide a minimum of two independent systems with two "back-bone" transmission circuits per system. The two systems are normally bused together to meet total power demand, and each system can accommodate full system power.

The energy storage assembly at ISS consists of hermetically-sealed, temperature-controlled, nickel-cadmium batteries, located at the Main Distributor Center in each Station module. These batteries provide all of the electrical power during eclipses. They also supply (1) supplemental

Table 7-15

LOW THRUST PROPULSION SUBSYSTEM DESIGN PARAMETERS

Propulsion	
Propellant	Biowaste CO_2
Capacity	28 lbm
Stowage Pressure	45 → 300 Psia
Stowage Tank	
Diameter	31 In.
Material	Titanium
Quantity	2
Thrustors	
Thrust Level	0.025 lbf/thrustor
ISP	175 sec (max)
	55 sec (min)
Chamber Pressure	45 Psia
Quantity	16/Module (100% Redundant)
Plumbing	
Propellant Lines	1/4 In. Diameter (Stainless Steel)
Non-Optimum	None
Quantity	100% Redundant

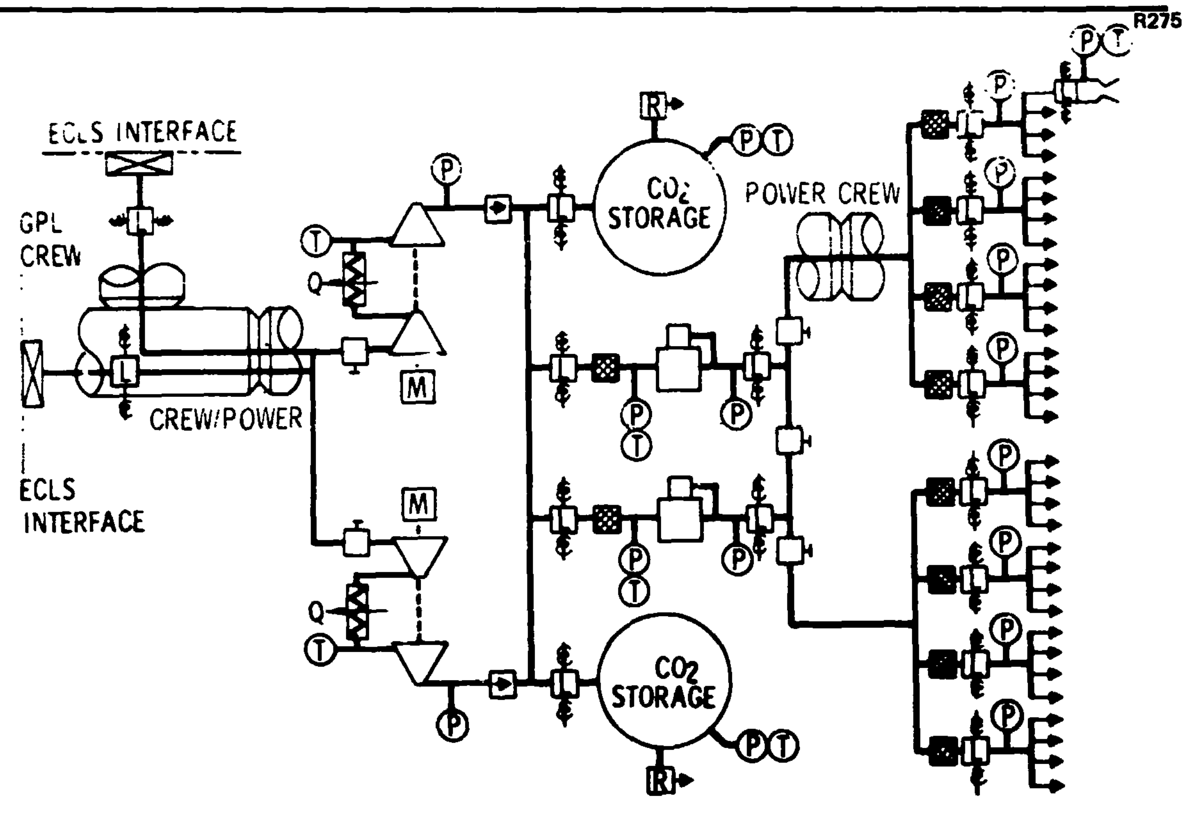


Figure 7-7. Low-Thrust Subsystem Schematic

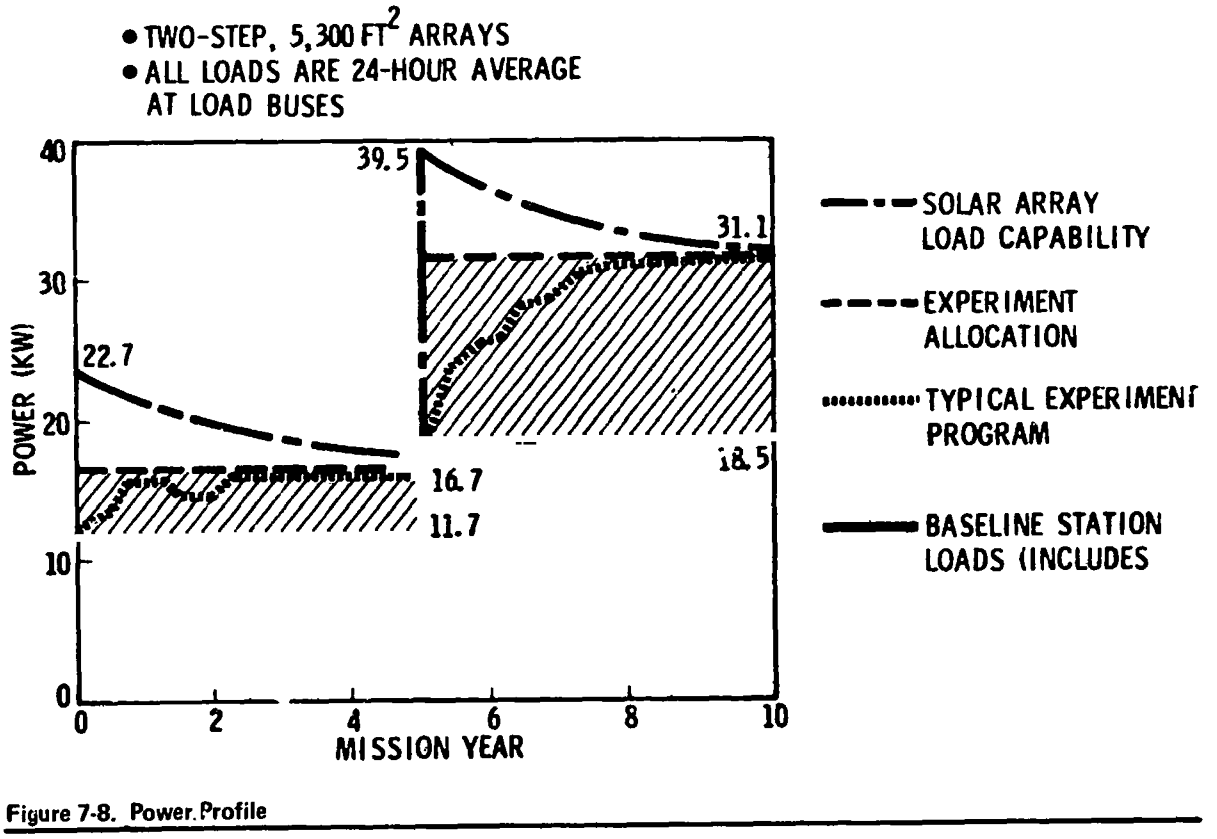


Figure 7-8. Power Profile

Table 7-16

INITIAL SPACE STATION ELECTRICAL LOAD REQUIREMENTS

Item	Power Value (Watts)
GNC	558
Ecls	2,320
Communications	321
Propulsion	385
DMS	4,116
EPS	218
Crew Systems	338
Lighting	1,256
Log Modules (2)	498
Distribution (3%)	300
Contingency (9.4%)	896
Subsystems Total	11,206
Experiments (W/GPL)	5,368
Experiments Distribution (3%)	161
Total Power	16,735

power during partial reductions of normal solar power, (2) emergency power in the event of loss of solar array power, (3) primary launch and ascent power for the Power/Subsystems Module, and (4) end-of-mission power when solar arrays are retracted for recovery.

The batteries are charged concurrently at low voltage by individual battery chargers. The batteries are discharged with four batteries in series to the associated main distributor bus at 115 ± 3 VDC through the PWM series buck load regulators. The battery energy is available to all Station modules through the transmission assembly.

The Power/Subsystems Module is launched with four batteries installed to provide power prior to array deployment. The array is deployed on-orbit and is operated in a minimum-drag (feathered) position until ISS manning occurs. The Crew/Operations Module and the GPL are launched without batteries and use Space Shuttle power until they are docked and are electrically connected to the Power/Subsystems Module power transmission system.

Figure 7-9 illustrates the total power system and Figure 7-10 the schematic.

The mass estimates were derived using the design parameters noted in Table 7-17. The Solar Array subsystem was based on data supplied by Lockheed Missiles and Space Company (LMSC A989270: dated 5/10/71). Basically their weights were updated to include various optimum and contingency allowance for the current baseline.

The batteries were sized for 100 AMP-Hours with 28 cells. The packaging weight of 36 percent is based on a nominal value which had a low of 14 percent to a high of 41 percent. The detail weight are included in Tables 7-18 through 7-20.

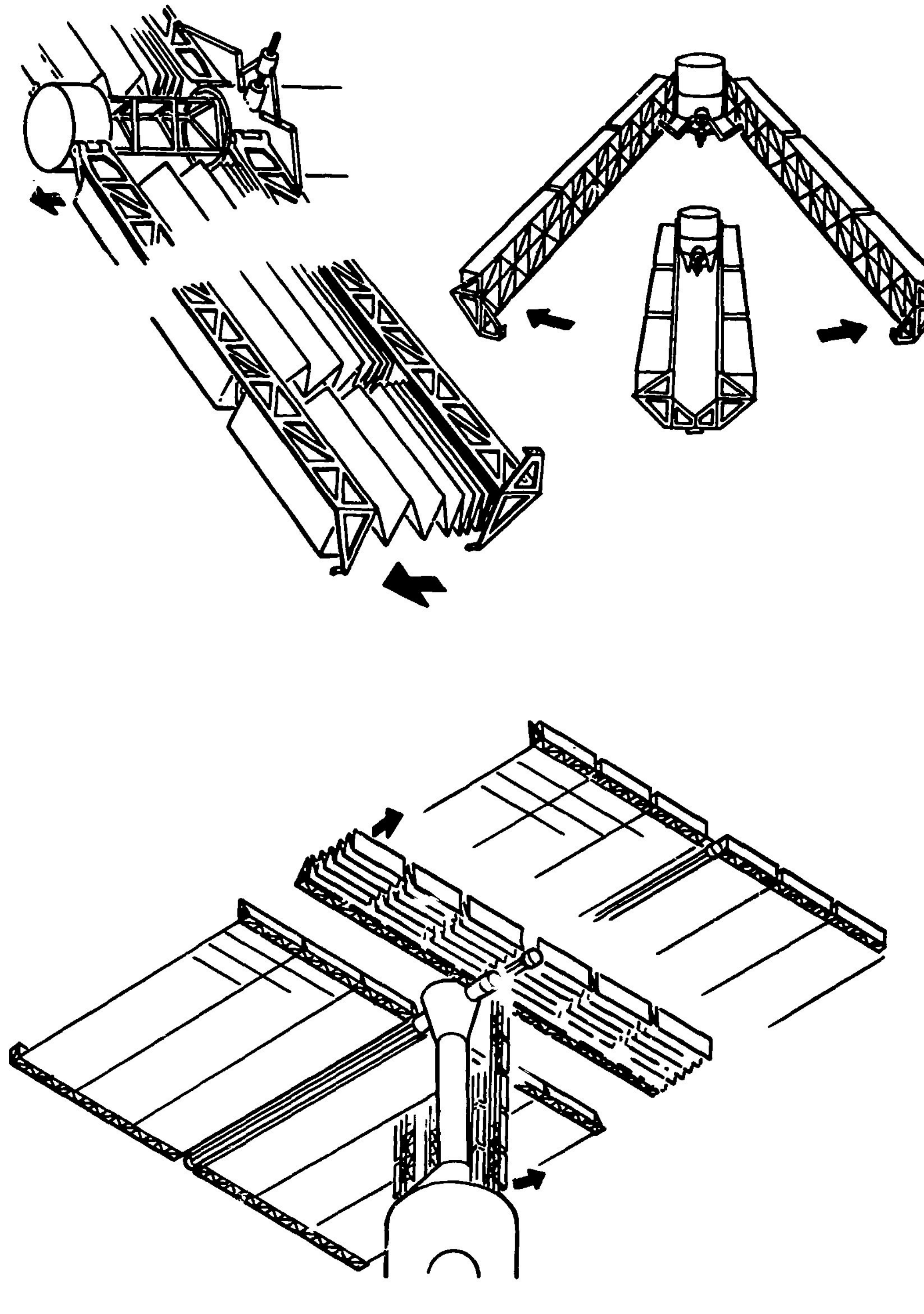


Figure 7-9. Solar Array System

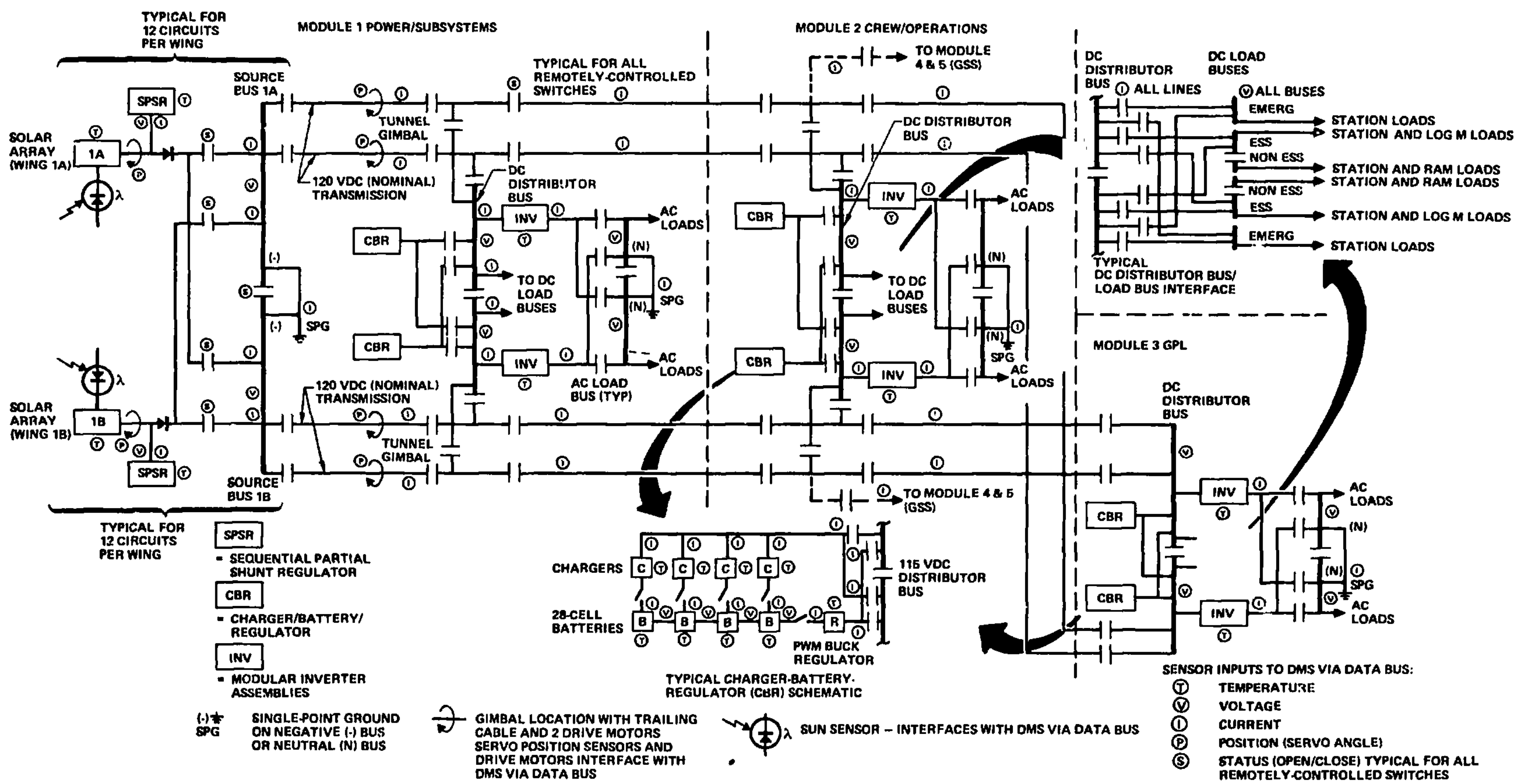


Figure 7-10. Prime Power Schematic (ISS)

Table 7-17

PRIME POWER DESIGN PARAMETERS

Solar Array	
Sunlight/Eclipse Period	56 Min/36 Min
Solar Cells	N/P Silicon
	8 mil cells with 6 mil covers
Voltage	120 vdc
Array Power	22.7 kw (initial) 16.7 kw (after 5 yrs)
Degradation Rates	30% in 5 yrs
Power Contingency	9.4%
Non-Optimum	5%
Size	4,500 ft^2
Astro Mast	
Diameter	36 in.
Length/Wing	62.5 ft.
Contingency	25%
Quadrant Container and Mechanism	
Contingency	15%
Waveguide Assembly	
Spline and Wave Generator	Titanium
Torquer Motor Quantity	1 per array wing
Contingency	5%
Batteries	
Cell Capacity	100 amp-hrs
Total ISS/GSS Batteries	24/40
Battery Weight	380 lbm
Depth of Discharge (Normal)	15% average/35% maximum
Depth of Discharge (Contingency)	30% average/70% maximum
Design Life (Normal)	2-1/2 yrs
Design Life (Contingency)	1 yr
Emergency Capacity (24 Batteries)	72 kr-hrs (full charge) 46.5 kw-hrs (65% charge)

Table 7-18
PRIME POWER DETAIL WEIGHT FOR POWER MODULE

		Unit Weight	Total ISS Req	Logistic Option Quantity	Logistic Option Total Weight	Power Module Initial Launch Quantity	Power Module Initial Launch Total Weight		
07.03	Batteries and Provisions						1,571		
	Battery Assembly							1,535	
	Battery Modules	280	24	4	1,120	4			1,120
	Packaging	100	24	4	400	4			400
	Attaching Parts	-	-	-	-	-			15
	Controls							36	
	Chargers	5	24	4	20	4			20
	Load Regulator	13	6	1	13	1			13
	Isolation Switches	0.3	54	9	3	9			3
	Spares				TBD	-			
07.04	Solar Array and Provisions						3,054		
	Solar Array							2,732	
	(1) Blankets	884	2			2			1,768
	*Turret	-	-			-			-
	(1) Astro Masts	268	2			2			536
	*Tunnel	-	-			-			-
	(1) Quadrant Containers	156	2			2			312
	(1) Quadrant Articulation	23	4			4			92
	Sensing Assy	24	1			1			24
	Tunnel or Mast Drive Assy							322	
	Flex Spline	18.8	3			3			56
	Circular Spline	17.3	3			3			52
	Wave Generator	16.1	3			3			48
	Drive Chain	2.3	3			3			7
	Motor/Gear	7.5	3			3			23
	Bearings	9.1	9			9			82
	Misc 20%	-	-			-			54
	Spares				TBD	-		-	
07.00	Prime Power				1,556		4,625 (2,098 Kg)		

*Functional Coded to Structure (FC 02.11)

(1) Contingency; Blanket 5%, Quadrant Container 15%, Quadrant Articulation 15%, and Astro Mast 25%

Table 7-19

PRIME POWER DETAIL WEIGHT FOR CREW MODULE

		Unit Weight	Total ISS Req	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight
07.03	Batteries and Provisions						15
	Battery Assembly						15
	Battery Modules	280	24	8	2,240	0	-
	Packaging	100	24	8	800	0	-
	Attaching Parts	-	-	-	-	-	15
	Controls						
	Chargers	5	24	8	40	0	
	Load Regulator	13	6	2	26	0	
	Isolation Switches	0.3	54	18	6	0	
	Spares				TBD	-	
07.04	Solar Array and Provisions						
	Solar Array						
	Blankets	884	2				
	*Turret		-				
	Astro Masts	268	2				-
	*Tunnel		-				-
	Quadrant Containers	156	2				
	Quadrant Articulation	23	4				
	Sensing Assembly	24	1				
	Tunnel or Mast Drive Assembly						
	Flex Spline	18.8	3				
	Circular Spline	17.3	3				
	Wave Generator	16.1	3				
	Drive Chain	2.3	3				
	Motor/Gear	7.5	3				
	Bearings	9.1	9				
	Misc	3	3				
	Spares				TBD	-	-
07.00	Prime Power				3,112		15 (7 Kg)

*Functional coded to structure (FC 02.11)

Table 7-20

PRIME POWER DETAIL WEIGHT FOR GPL MODULE

				Logistic Options		Initial Launch	
		Unit Weight	Total ISS Req	Quan- tity	Total Weight	Quan- tity	GPL Module Total Weight
07.03	Batteries and Provisions						15
	Battery Assembly						15
	Battery Modules	280	24	8	2,240	0	
	Packaging	100	24	8	800	0	
	Attaching Parts	-	-	-	-		15
	Controls						
	Chargers	5	24	8	40	0	
	Load Regulator	13	6	2	26	0	
	Isolation Switches	0.3	54	18	6	0	
	Spares				TBD	-	
07.04	Solar Array and Provisions						
	Solar Array						
	Blankets	884	2				
	*Turret						
	Astro Masts	268	2				
	*Tunnel						
	Quadrant Containers	156	2				
	Quadrant Articulation	23	4				
	Sensing Assembly	24	1				
	Tunnel or Mast Drive Assembly						
	Flex Spline	18.8	3				
	Circular Spline	17.3	3				
	Wave Generator	16.1	3				
	Drive Chain	2.3	3				
	Motor/Gear	7.5	3				
	Bearings	9.1	9				
	Misc	3	3				
	Spares				TBD	-	-
07.00	Prime Power				3,112		15 (7 Kg)

*Functional codes to structure (FC 02.11)

7.6 POWER CONVERSION AND DISTRIBUTION (FC 08.00)

Power conversion and distribution is made up of the Power Control and Regulation Assembly which provides solar array voltage regulation. The regulation system uses a sequential partial shunt regulation (SPSR) technique to provide a full linear range of voltage control.

The transmission, conditioning, and distribution (TCD) assemblies consitüte the power transfer and power processing assemblies. These include switching and protection in the transmission and distribution assemblies, battery charging, regulation and DC/AC inversion in the conditioning assembly. The inverter modules operate in parallel within each Station module with no paralleling between modules. Power transfer between major Station modules occurs only through the 115 vdc transmission assembly, and power transfer to Log-M's and RAM's occurs only through load bus feeders in the distribution assembly.

A single point ground is provided for each electrically independent (isolated) system. Structure ground points are provided for connections of the negative DC source buses and each AC load bus neutral.

The electrical power management function is provided by integrated subassemblies located in the Prime Power System and the DMS. It includes monitor and processing functions to control Prime Power System switching, array voltage regulation, array orientation drive control as required by sun-acquisition computations and solar-tracking sensors, and battery charging and discharging electronics.

Table 7-21 through 7-23 summarizes the weights. The weights were based on information supplied by Westinghouse Corporation for similar existing components. The units were scaled to the peak loads capability and the efficiency optimized for the average load. The power protection and distribution panel weights are based on data for similar units on the MOL program.

Table 7-21

POWER CONVERSION AND DISTRIBUTION DETAIL WEIGHTS FOR POWER MODULE

		Unit Weight	Total ISS Req	Logistic Options		Power Module Initial Launch			
				Quantity	Total Weight	Quantity	Total Weight		
08.01	Power Conditioning - AC						80		
	Inverters							80	
	3PH 400 Hz Sine	12	12			4			48
	3PH 400 Hz Quad SA	8	10			4			32
	1PH 60 Hz Sine	18	2			-			-
08.02	Power Conditioning - DC						256		
	SEQ Part Shunt Regulator	128	2	-	-	2		256	
08.04	Power Distribution - AC						52		
	Power Control Unit	7	2			1		7	
	Distribution Panels/ Circuit/Breakers	-	-					45	
08.05	Power Distribution - DC						278		
	Source Bus	140	1					140	
	Distribution Panels/ Circuit Breakers	-	-					53	
	Distribution Bus/Relays	-	-					85	
Misc							7		
	Attaching Parts	-	-		-			7	
	Spares	-	-		TBD			-	
08.00	Power Conditioning and Distribution						673 (305 Kg)		

Table 7-22

POWER CONVERSION AND DISTRIBUTION DETAIL WEIGHTS FOR CREW MODULE

		Unit Weight	Total ISS Req	Logistic Options		Power Module Initial Launch			
				Quantity	Total Weight	Quantity	Total Weight		
08. 01	Power Conditioning - AC						72		
	Inverters							72	
	3PH 400 Hz Sine	12	12			4			48
	3PH 400 Hz Quad SA	8	10			3			24
	1PH 60 Hz Sine	18	2			-			-
08. 02	Power Conditioning - DC						-		
	SEQ Part Shunt Regulator	128	2	-	-			-	
08. 04	Power Distribution - AC						42		
	Power Control Unit	7	2			1		7	
	Distribution Panels/ Circuit Breakers	-	-					35	
08. 05	Power Distribution - DC						170		
	Source Bus	140	1					-	
	Distribution Panels/ Circuit Breakers	-	-					66	
	Distribution Bus/Relays	-	-					104	
Misc									
	Attaching Parts	-	-		-		3	3	
	Spares	-	-		TBD			-	
08. 00	Power Conditioning and Distribution						287 (130 Kg)		

Table 7-23

POWER CONVERSION AND DISTRIBUTION DETAIL WEIGHTS FOR GPL MODULE

		Unit Weight	Total ISS Req	Logistic Options		GPL Module Initial Launch			
				Quantity	Total Weight	Quantity	Total Weight		
08.01	Power Conditioning - AC						108		
	Inverters							108	
	3PH 400 Hz Sine	12	12			4			48
	3PH 400 Hz Quad SA	8	10			3			24
	1PH 60 Hz Sine	18	2			2			36
08.02	Power Conditioning - DC								
	SEQ Part Shunt Regulator	128	2	-	-		-	-	
08.04	Power Distribution - AC						35		
	Power Control Unit	7	2					-	
	Distribution Panels/ Circuit Breakers	-	-					35	
08.05	Power Distribution - DC						142		
	Source Bus	140	1					-	
	Distribution Panels/ Circuit Breakers	-	-					92	
	Distribution Bus/Relays	-	-					50	
Misc							3		
	Attaching Parts	-	-		-			3	
	Spares	-	-		TBD			-	
08.00	Power Conditioning and Distribution						288 (131 Kg)		

The electrical power system schematic previously mentioned (Figure 7-9) illustrates the major elements and their relative interfaces.

7.7 VEHICLE ELECTRONIC (FC 10.00)

The vehicle electronics included in this functional code consists of guidance and control (FC 10.01), onboard checkout (FC 10.02), data management (FC 10.03), communication (FC 10.06), and display and controls (FC 10.15). Each is detailed in the following sections with the weight deviations noted. No contingency was supplied (FC 10.19) as conservative estimates were used in all cases.

7.8 GUIDANCE AND CONTROL (FC 10.01)

The guidance and control system provides for Station attitude control and stabilization, navigation and orbit-keeping, and rate data for experiment support. A schematic diagram of the guidance and control system appears in Figure 7-11 with Figure 7-12 illustrating the flight orientation.

The GNC subsystem senses, computes, and receives the commands and data for these functions while the Propulsion subsystem and the control moment gyros generate the actuation forces and torques needed for attitude control. Sensing and computation of Station attitude and angular rates are provided within the Station while the navigation data is provided by the ground tracking network.

The GNC subsystem provides the Modular Space Station with the capability to maneuver and hold any orientation to support the orbital and experiment operations in the presence of the orbital disturbance environment. The Station can accommodate any inertial orientation for an indefinite time period subject to propellant expenditure and potential contamination associated with use of the high-thrust system. Normal attitude control is performed by control moment gyros (CMGs) which provide sufficient capacity for the cyclic disturbances of the worst-case orientation. The GNC subsystem sensors, gyro triads, star sensor, horizon sensor and star trackers which provide the all-attitude capability are located in the Power Module. The star sensor and gyro triads provide the primary trimmed horizontal reference. The horizon sensors are used to provide the acquisition of the Earth-centered reference

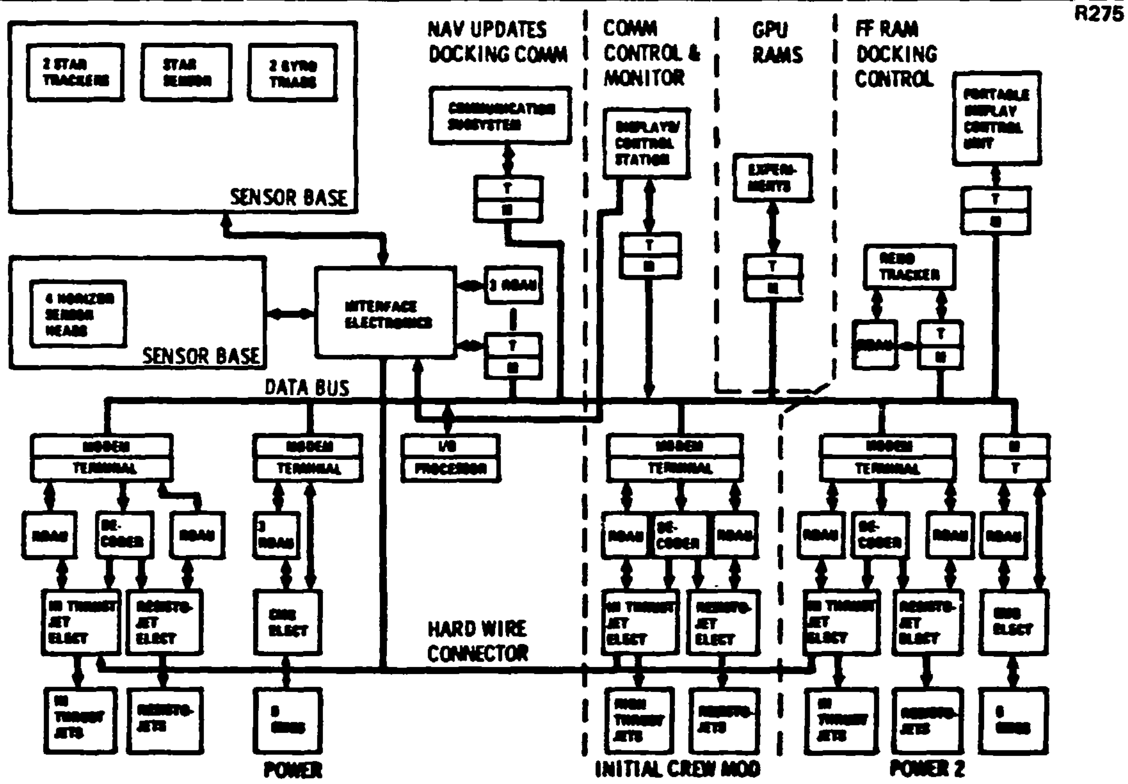
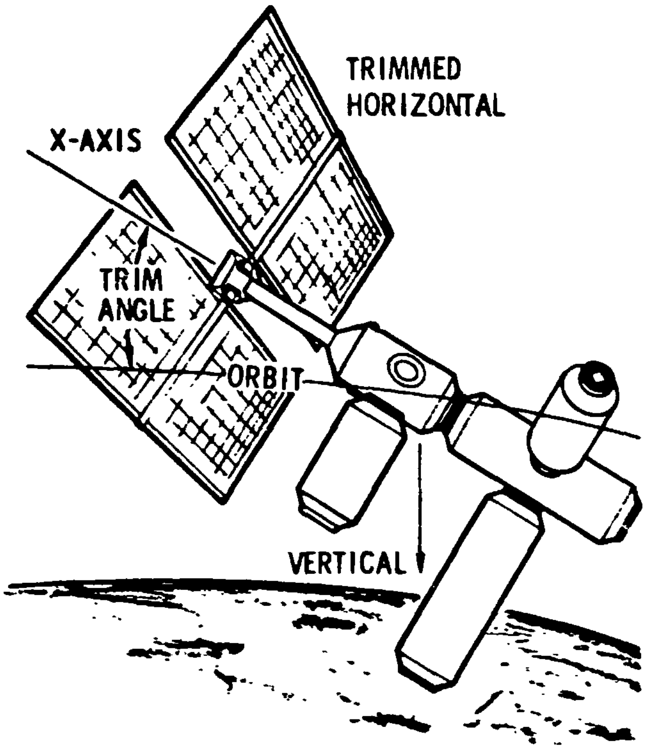


Figure 7-11. Guidance and Navigation Subsystem Schematic

and are also used with the gyro triads to provide a limited trim or untrimmed horizontal reference. Four control moment gyros (CMGs) provide primary control actuation. A fifth CMG is in a standby mode (spare).

The data for weights are based on the following sources. The inertial reference unit is based on data from Honeywell and is their existing type GG334 Gyro. The horizon sensor is an adaptation of a unit made by Barnes Engineering and used on the X-15 vehicle. The existing unit is a three-sensing-head design weighing 10 lb; the proposed unit uses four sensing heads, and the weight is estimated to have increased to 13 lb. The gimballed star

R275



ORIENTATIONS	PROPELLANT (LB/DAY)
EARTH CENTERED:	
TRIMMED HORIZONTAL	<1
HORIZONTAL	38
TRIMMED X-POP/OR	<1
WORST CASE	450
INERTIAL:	
AVERAGE	41
WORST	260
TRIMMED X-POP	<1

Figure 7-12. Flight Orientation

tracker is the unit used on the OAO and manufactured by Bendix. The star sensors are existing units manufactured by Honeywell. The horizon sensor is an existing unit, Model 13-2055C, manufactured by Barnes Engineering. The sensor interface electronic weights are based on estimates by Honeywell. The processor weight is based on information from IBM.

Table 7-24 summarizes the key design specifications with Tables 7-25 through 7-27 summarizing the detail weight summary.

7.9 ONBOARD CHECKOUT (FC 10.02)

The Onboard Checkout System (OCS) provides checkout and fault isolation support of ISS integral subsystems and experiments, as well as limited support of subsystems and experiments within docked modules. The OCS is utilized as the primary checkout and dault isolation tool during post-manufacturing, prelaunch, on-orbit buildup, and on-orbit operational phases of the ISS program.

Table 7-24

GUIDANCE AND CONTROL DESIGN PARAMETERS

Altitude	270→246 nmi (500→455 km)
Orientation	
Primary	Trimmed Horizontal
Others	All Attitudes
Attitude Control	±0.25 Degrees
Navigation	±1.0 nmi (±1.86 km)
Momentum Storage Requirements	
Roll Axis	4,720 lb-ft-sec
Pitch Axis	7,580 lb-ft-sec
Yaw	7,160 lb-ft-sec
Momentum Storage Capability	
Roll Axis	6,000 lb-ft-sec
Pitch Axis	12,000 lb-ft-sec
Yaw Axis	12,000 lb-ft-sec
CMG	
Total Weight	400 lb/each
Envelope	42 x 43 x 40 in.
Type	Advanced 2,000H
Quantity	5 (1 on line spare)

The system takes advantage of ISS data management capabilities in the areas of data acquisition and distribution, computation, data storage, displays and controls, command generation, and operating system software. Special processing and stimuli-generation capabilities that are integral to other subsystem and experiment equipment are also utilized. Capabilities unique to the OCS, however, are provided for stimuli generation, critical measurements, and checkout software.

An overall block diagram depicting OCS elements is provided in Figure 7-13. Stimuli generation, command generation, and data acquisition capabilities are distributed throughout the ISS as dictated by checkout data point locations.

Table 7-25

GUIDANCE AND CONTROL DETAIL WEIGHT SUMMARY FOR POWER MODULE

	Unit Weight	Total ISS Req	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight		
Attitude Control						117		
Inertial Reference							54	
Gyroscope Assy	25	2			2			50
Gyro Mount	4	1			1			4
Horizon Sensor							13	
Horizon Sensor	11	1			1			11
Sensor Mount	2	1			1			2
Interface Electronics	30	2			1		30	
Reaction Control Electronics	20	2			1		20	
Precision Reference						96		
Star Tracker	40	2			2		80	
Star Sensor	16	1			1		16	
Control Moment Gyros						120		
Control Moment Gyro	400	4	4	1,600			--	
CMG Control Electronics	10	2	2	20			--	
Support Provisions	--	--	--	--			120	
Spares						--		
CMG	400	1	1	400			--	
Misc	--	--	--	--			--	
Misc							10	
Attaching Parts				12				10
10.01 Guidance and Control				2,032			343 (156 Kg)	

Table 7-26

GUIDANCE AND CONTROL DETAIL WEIGHT SUMMARY FOR CREW MODULE

	Unit Weight	Total ISS Req	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight		
Attitude Control						50		
Inertial Reference							--	
Gyroscope Assembly	25	2						--
Gyro Mount	4	1						--
Horizon Sensor								
Horizon Sensor	11	1						--
Sensor Mount	2	1						--
Interface Electronics	30	2			1		30	
Reaction Control Electronics	20	2			1		20	
Precision Reference						--		
Star Tracker	40	2					--	
Star Sensor	16	1					--	
Control Moment Gyros						--		
Control Moment Gyro	400	5					--	
CMG Control Electronics	10	2					--	
Spares				549		--		
Misc						6		
Attaching Parts				--			6	
10.01 Guidance and Control				549		56 (25 kg)		

Table 7-27

GUIDANCE AND CONTROL DETAIL WEIGHT SUMMARY FOR GPL MODULE

	Unit Weight	Total ISS Req	Logistic Options		Initial Launch			
			Quan-tity	Total Weight	Quan-tity	Total Weight		
Attitude Control						--		
Inertial Reference							--	
Gyroscope Assembly	25	2						--
Gyro Mount	4	1						--
Horizon Sensor							--	
Horizon Sensor	11	1						--
Sensor Mount	2	1						--
Interface Electronics	30	2	--	--			--	
Reaction Control Electronics	20	2	--	--			--	
Precision Reference						--		
Star Tracker	40	2					--	
Star Sensor	16	1					--	
Control Moment Gyros						--		
Control Moment Gyro	400	5					--	
CMG Control Electronics	10	2					--	
Spares			--			--		
Misc						--		
Attaching Parts							--	
10.01 Guidance and Control						0		

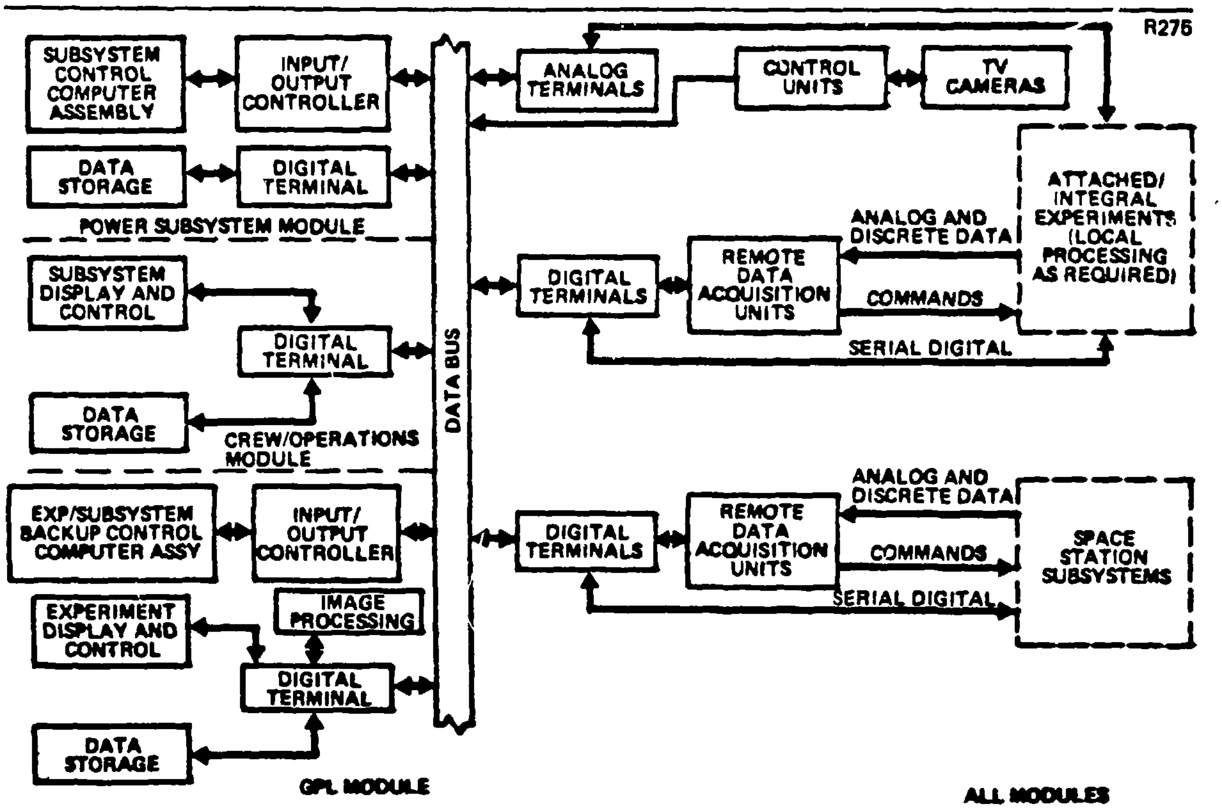


Figure 7-13. MSS Data Management Subsystem

Local caution and warning units are located in each habitable compartment with overall status provided at both the primary and secondary ISS control centers.

The remote data-acquisition unit weight is based on an estimate by IBM. The weight of the stimuli generation is based on the weight of a prototype model built by Martin Company. The digital data terminal weight is an estimate from IBM. The local caution and warning panel weight is an extrapolation of MOL data. The sensor quantity is an estimate, with conservative unit weights being selected for the weight estimate.

Tables 7-29 through 7-31 provide a weight summary of the Onboard Checkout Subsystem. Key OCS specifications are shown in Table 7-28.

Table 7-28

ONBOARD CHECKOUT DESIGN FEATURES

Function	Characteristics
• Remote Checkout Data Acquisition	• Computer-controlled • Random or sequential sampling • Remotely programmable limits • Digital inputs: 8 parallel bits or serial data $\leq 1 \times 10^6$ BPS per channel • Analog inputs: 0-40 mv, 0-5 vdc
• Stimuli and Command Generation	• Computer-controlled • Analog outputs: 0-115 vdc • Momentary or continuous 5 vdc signals • Serial digital data
• Checkout and Fault Isolation Control	• General-purpose displays and controls (portable and fixed) • Automatic operation • Restructurable application programs
• Critical Measurements	• Local monitor and display units • Centralized displays • Audio and visual alarms

7.10 DATA MANAGEMENT (FC 10.03)

The data management subsystem (DMS) provides transfer, storage, and processing for Modular Space Station users, subsystems and experiments. Control of ISS operation is provided through standard data bus terminals and appropriate digital and analog interface equipment under computer control.

Table 7-29

ONBOARD CHECKOUT DETAIL WEIGHT SUMMARY FOR POWER MODULE

		Unit Weight	Total ISS Req	Logistic Options		Initial Launch			
				Quan-tity	Total Weight	Quan-tity	Total Weight		
10.02	Data Acquisition and Transfer						300		
	Data Bus							105	
	Terminal Analog	5	3						
	Terminal Digital	5	50			21			105
	Timing							20	
	Time Ref Unit	10	2			2			20
	Instrumentation							100	
	Subsystem XDCR	--	350			100			100
	Experiment XDCR	--	50						-
	Remote Data Acquisition							42	
	RDAU	1	93			42			42
	Command							5	
	Command Interface	5	2			1			5
	Television							28	
	External TV Camera	4	3			-			-
	Interior TV Camera	4	7			2			8
	TV Control Unit	10	10			2			20
	Unique Checkout Equipment						96		
	Stimuli Gen Unit	12	12			7		84	
	Local C/W Unit	4	18			3		12	
	Misc						4		
	Attaching Parts							4	
	Spares			TBD					
	Contingency					--			
Onboard Checkout							400 (181 Kg)		

Table 7-30

ONBOARD CHECKOUT DETAIL WEIGHT SUMMARY FOR CREW

		Unit Weight	Total ISS Req	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight		
10.02	Data Acquistion and Transfer						331		
	Data Bus							80	
	Terminal Analog	5	3						
	Terminal Digital	5	50			16			80
	Timing								
	Time Ref Unit	10	2						
	Instrumentation							150	
	Subsystem XDCR		350			150			150
	Experiment XDCR		50						
	Remote Data Acquisition							31	
	RDAU	1	93			31			31
	Command								
	Command Interface	5	2						
	Television							70	
	External TV Camera	4	3			3			12
	Interior TV Camera	4	7			2			8
	TV Control Unit	10	10			5			50
	Unique Checkout Equipment						72		
	Stimuli Gen	12	12			3		36	
	Local C/W Unit	4	18			9		36	
	Misc						4		
	Attaching Parts							4	
	Spares							--	
	Contingency					--		--	
Onboard Checkout							407 (185 Kg)		

Table 7-31

ONBOARD CHECKOUT DETAIL WEIGHT SUMMARY FOR GPL

	Unit Weight	Total ISS Req	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight		
10.02 Data Acquisition and Transfer						297		
Data Bus							80	
Terminal Analog	5	3			3			15
Terminal Digital	5	50			13			65
Timing								
Time Ref Unit	10	2						
Instrumentation							150	
Subsystem XDCR		350			100			100
Experiment XDCR		50			50			50
Remote Data Acquisition							20	
RDAU	1	93			20			20
Command							5	
Command Interface	5	2			1			5
Television							42	
External TV Camera	4	3			--			--
Interior TV Camera	4	7			3			12
TV Control Unit	10	10			3			30
Unique Checkout Equipment						48		
Stimuli Gen Unit	12	12			2		24	
Local C/W Unit	4	18			6		24	
Misc						3		
Attaching Parts							3	
Spares			TBD				--	
Contingency					--		--	
Onboard Checkout						348 (158 Kg)		

Crew access to computer operations is provided through keyboard and display equipment. A schematic of the Data Management Subsystem is shown in Figure 7-13.

Two computer complexes are provided, one in the Power/Subsystems Module for subsystems operations and the other in the GPL Module for experiment operations. Each of the computer complexes is a modular multiprocessor. For backup the experiment multiprocessor can be rapidly reconfigured to perform the subsystem operation functions. The majority of the data-computation subsystem weights were supplied by IBM, in their role as an associate contractor.

The computer's auxiliary memories provide the capability for reading a variety of stored programs into the computer main memory on an as-needed basis. New programs will be generated, as required, on the ground and transmitted (via RF links) or carrier (via a logistics module flight) to the Modular Space Station. The crew can also initiate program changes through the alpha-numeric keyboards. The file tape transports on the equipment list provide the highest level of memory in the computation memory hierarchy for infrequently used data and are identical to the digital bulk storage units.

Bulk data storage utilizes ultra-high density magnetic tape recording techniques and is configured to meet high data volume storage requirements and relatively slow access speed requirements. The storage is used primarily for digital data recording prior to onboard processing or return to Earth via Logistics Module/Shuttle Orbiter for ground processing. Magnetic tape recorders also provide for storage of voice and analog data.

Image processing equipment provides a capability for selected processing of high-resolution video data, for transforming film data into electronic signals, or both. Tape storage for experiment video is also provided.

Table 7-32 provides the key specifications for the Data Management Subsystem. Tables 7-33 through 7-35 provide a weight summary of the Data Management Subsystem.

Table 7-32

DATA MANAGEMENT SUBSYSTEM DESIGN SPECIFICATION

Data sources:	2,790 analog (≤ 10 KHz bandwidth) 24 analog (> 10 KHz bandwidth) 1,480 discrete 160 digital serial (data sources and commands)
Digital serial rate:	1 megabit per sec
Discrete commands:	1,480
Analog data voltage:	0 to 40 mv or 0 to 5 v full scale
Analog-to-digital conversion:	8-bit accuracy
Remote limit checking:	Bit-by-bit comparison of 7-bit words
No. of digital data bus channels:	3 expandable up to 8
Digital data bus channel rate:	10 megabits per sec
Number of analog data bus channels:	1 public address 1 telephone carrier reference 1 emergency call tone 1 emergency alert tone 36 telephones 3 entertainment 1 television carrier reference 8 television and video 1 onboard generated test
Digital data bus terminations:	128
Analog data bus terminations:	64 maximum
Digital data bus addressing:	Up to 1,024 unique devices

Table 7-32

DATA MANAGEMENT SUBSYSTEM DESIGN SPECIFICATION (Continued)

Computing processing rate:	At least 1,213,000 operations per second
Main memory capacity:	At least 192,000 32-bit words
Auxiliary memory capacity:	At least 1,376,000 32-bit words
Digital data recording rate:	At least 2.5×10^7 bits/sec
Digital data storage capacity:	10^{10} bits minimum per tape reel
Video recording frequency response:	4.5 MHz at 3 db
Video recording time:	3 hrs minimum per reel
Multipurpose display capability:	96 ASCII alpha-numeric character set 1250 characters per frame 800 lin in. per frame for graphics
Video display capability:	525 commercial standard TV lines

7.11 COMMUNICATIONS (FC 10.06)

Direct communications with the ground stations are provided by a 1 w S-Band transponder which receives voice commands and ranging information and transmits voice, telemetry and ranging data. An S-Band FM exciter and power amplifier is also provided for the transmission of video and digital experiment data. Two-way voice, low rate data, and ranging communications with the shuttle are also provided by the same S-Band transponder used for direct ground communications. However, a power amplifier operating in conjunction with the transponder is required to provide simultaneous voice, data and ranging at ranges up to 200 km. A common low-gain S-Band antenna system will be utilized for communications with both the ground and the Shuttle.

Table 7-33

DATA MANAGEMENT DETAIL WEIGHT SUMMARY FOR POWER MODULE

	Unit Weight	Total ISS Req	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight		
Computation						190		
Subsystem Computer System							190	
Processor	15	2			2			30
Main Memory 16 K	20	6	2	40	4			80
Input/Output Control	20	2			2			40
Auxiliary Memory	20	2			2			40
File Tape Transport	40	1						
Experiment Computer								
Processor	15	2						
Main Memory 16 K	20	5						
Input/Output Control	20	2						
Auxiliary Memory	20	2						
File Tape Transport	40	1						
Image Processing						0		
Film Viewer	148	1						
Film Digitizer	198	1						
Multichannel Filter	20	1						
Processor	15	1						
Console	65	1						
Per Video Storage	100	1						
Per Digital Storage	40	1						
Work Video Storage	12	1						
Data Storage						45		
Digital Storage Assembly							45	
Digital Recorders	40	3			1			40
Buffer and Control	5	3			1			5
Analog Storage Assembly								
Analog Recorders	100	3						
Audio Recorders	5	8						
Crew Audio/Visual	20	8						
Miscellaneous					--	2		
Attaching Parts							2	
Spares			TBD					
7.11 Data Management				40		237 (107 kg)		

Table 7-34

DATA MANAGEMENT DETAIL WEIGHT SUMMARY FOR CREW

	Unit Weight	Total ISS Req	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight
Computation						40
Subsystem Computer System						40
Processor	15	2				
Main Memory 16 K	20	6				
Input/Output Control	20	2				
Auxiliary Memory	20	2				
File Tape Transport	40	1			1	40
Experiment Computer						
Processor	15	2				
Main Memory 16 K	20	5				
Input/Output Control	20	2				
Auxiliary Memory	20	2				
File Tape Transport	40	1				
Image Processing						0
Film Viewer	148	0				
Film Digitizer	198	1				
Multichannel Filter	20	1				
Processor	15	1				
Console	65	1				
Per Video Storage	100	1				
Per Digital Storage	40	1				
Work Video Storage	12	1				
Data Storage						280
Digital Storage Assembly						
Digital Recorders	40	3				
Buffer and Control	5	3				
Analog Storage Assembly						120
Analog Recorders	100	3			1	100
Audio Recorders	5	8			4	20
Crew Audio/Visual	20	8			8	160
Miscellaneous						3
Attaching Parts						3
Spares					TBD	
7.11 Data Management						323 (147 kg)

Table 7-35

DATA MANAGEMENT DETAIL WEIGHT SUMMARY FOR GPL

	Unit Weight	Total ISS Req	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight
Computation						250
Subsystem Computer System						
Processor	15	2				
Main Memory 16 K	20	6				
Input/Output Control	20	2				
Auxiliary Memory	20	2				
File Tape Transport	40	1				
Experiment Computer						250
Processor	15	2			2	30
Main Memory 16 K	20	5			5	100
Input/Output Contrcl	20	2			2	40
Auxiliary Memory	20	2			2	40
File Tape Transport	40	1			1	40
Image Processing						65
Film Viewer	148	1	1	148		
Film Digitizer	198	1	1	198		
Multichannel Filter	20	1	1	20		
Processor	15	1	1	15		
Console	65	1			1	65
Per Video Storage	100	1	1	100		
Per Digital Storage	40	1	1	40		
Work Video Storage	12	1	1	12		
Data Storage						310
Digital Storage Assembly						90
Digital Recorders	40	3	1	40	2	80
Buffer and Control	5	3			2	10
Analog Storage Assembly						220
Analog Recorders	100	3			2	200
Audio Recorders	5	8			4	20
Crew Audio/Visual	20	8				
Miscellaneous						6
Attaching Parts						6
Spares			TBD			
7.11 Data Management				493		631 (286 kg)

Communications with the DRS are provided by K_u-Band transmitting and receiving systems. An 8-ft diameter high-gain antenna is required to provide for commercial quality television. Multiple voice channels and turned-around ranging transmissions are provided simultaneously with the wideband transmission on a separate carrier. Simultaneous reception of multiple voice, medium rate data, and ranging information is also provided.

Two-way voice and low data rate communications between the Space Station and DRSS are also provided in the VHF band. These links utilize a low-gain antenna system which will provide nearly omnidirectional coverage.

Full duplex voice communications with crewmen engaged in extravehicular activity (EVA) and the reception of crew biomedical telemetry are provided. These channels will be multiplexed into the VHF antenna system used for relay satellite communications.

Assembly level descriptions of the Communications equipment were provided by Collins Radio Company and Radiation Inc. under a funded study. RF and Internal Communications data were provided by Collins Radio Company and High Gain Antenna System data were provided by Radiation Inc. Additional details can be found on this subsystem in SE-04, section 4.9

The Communication Subsystem schematic is illustrated in Figure 7-14 with design specifications in Table 7-36.

Tables 7-37 through 7-39 provide a weight summary of the Communications Subsystem.

7.12 DISPLAY AND CONTROLS (FC 10.15)

The display and control system supplies the crew with the capability to control and monitor the Space Station subsystems and experiments. To reduce crew monitoring and controlling time, a digital computer complex manages and controls most of the equipment operations. The display and controls most of the equipment operations. The display and controls are located in the crew module with the experiment command and control center located in

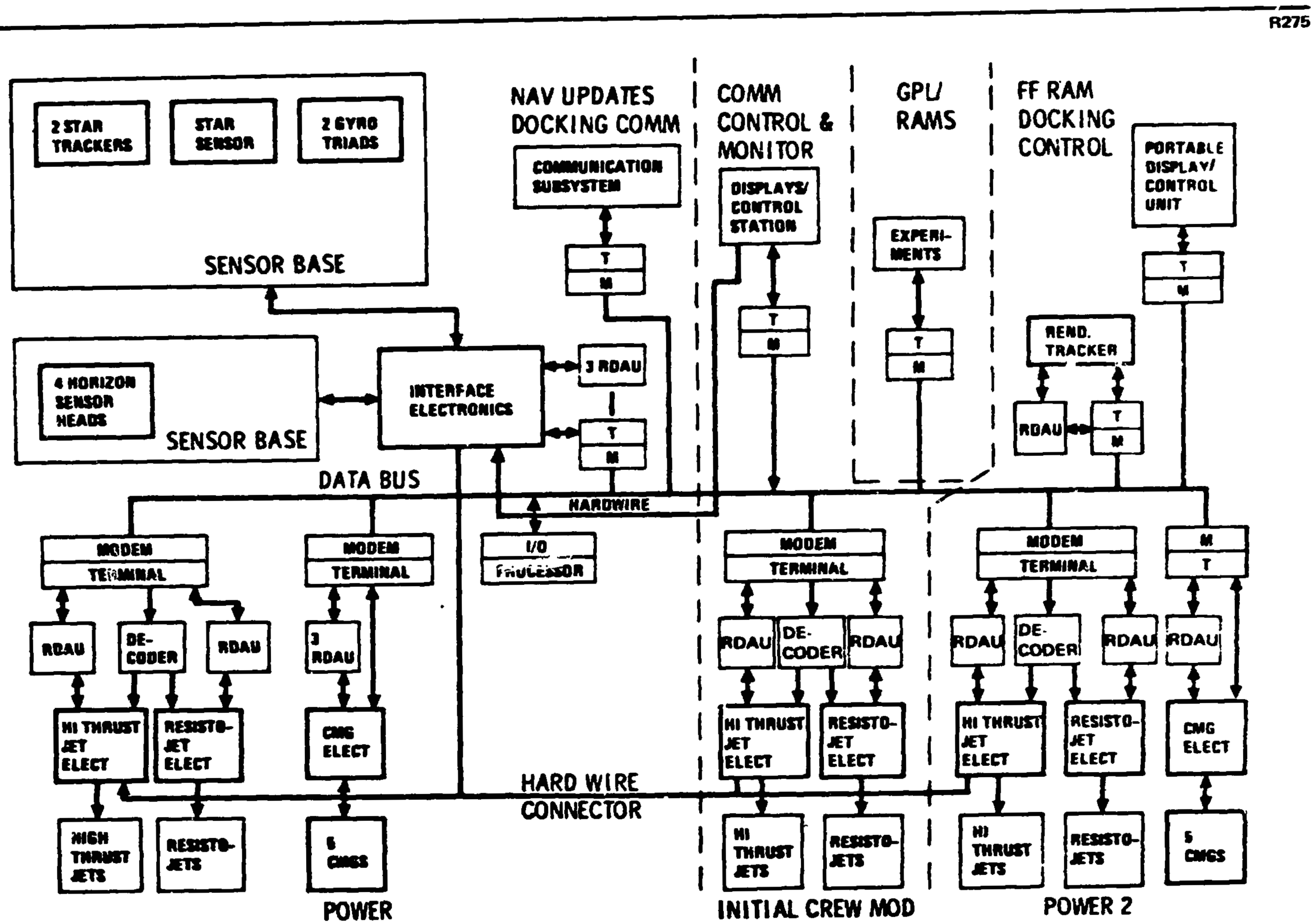


Figure 7–14. Communications Subsystem Schematic

Table 7-36

COMMUNICATIONS SUBSYSTEM DESIGN SPECIFICATIONS

VHF System	
Frequency range:	126 to 144 MHz and 250 to 300 MHz
Antenna type:	Low gain (omni)
Transmitter power:	20 w and 1 mw
Receiver noise figure:	4 db
S-Band System	
Frequency range:	2.1 and 2.3 GHz
Antenna Type:	Low gain (omni)
Transmitter power:	20 w and 1 w
Receiver noise figure:	6 db
K_u-Band System	
Frequency Range:	13.4 to 15.4 GHz
Antenna Type:	8 ft parabolic reflector
Transmitter power:	20 w/channel
Receiving system temperature:	1,000° Kelvin
Internal Communications System	
Baseband emergency voice channel	
36 audio subcarriers on analog bus	
18 audio terminals	

Table 7-37

COMMUNICATIONS DETAIL WEIGHTS FOR POWER MODULE

	Unit Weight	Total ISS Req	Logistic Options: Quantity	Logistic Options: Total Weight	Initial Launch: Quantity	Initial Launch: Total Weight		
RF Communication						249		
VHF/RF Assembly Group							60	
Voice XMTR/RCUR	12	2			2			24
Data XMTR/RCUR	10	2			2			20
EVA XMTR/RCUR	2	3			3			6
EVA T/R MODEM	10	1			1			10
S-Band RF Assembly Group							66	
FM Transponder	23	2			2			46
FM Exciter	3	1			1			3
Power Amplifier	5	2			2			10
Ranging Unit	7	1			1			7
SHF RF Assembly Group								
S-Band NB PM RCUR	20	1						
S-Band WB FM RCUR	25	1						
KU Exciter MODEM	6	6						
Low-Gain Antenna Group							123	
VHF Antenna Element	15	3			3			45
VHF Diplexer	3	3			3			9
VHF Multiplexer	6	2			2			12
S-Band Antenna	2	3			3			6
S-Band Triplex Switch	3	1			1			3
VHF/S-Band Coax	8	6			6			48
High-Gain Antenna*								
Reflector and Feed	31	3						
Position and Service Control	30	3						
Thermal Control	10	3						
KU Power Amplifier	10	6						
KU Exciter	3	6						
KU Low Noise RCUR	5	6						
S-Band Track RCUR	5	6						
Microwave Network	10	3						
Misc	15	3						
Mast	40	3						
Internal Communications						54		
Int Comm Assembly Group							54	
Audio Terminals	4	18			3			54
Analog Synchronize Test	5	2			-			-
Miscellaneous						3		
Attaching Parts							3	
Spares				TBD				
10.06 Communications						306 (139 Kg)		

*At GSS level an additional antenna would be added at the end of the power astro-mast; this would be smaller than the baseline design.

Table 7-38

COMMUNICATIONS (10. 06) DETAIL WEIGHTS FOR CREW MODULE

	Unit Weight	Total ISS Req	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight
RF Communication						627
VHF/RF Assembly Group						
Voice XMTR/RCUR	12	2				
Data XMTR/RCUR	10	2				
EVA XMTR/RCUR	2	3				
EVA T/R MODEM	10	1				
S-Band RF Assembly Group						
PM Transponder	23	2				
RM Exciter	3	1				
Power Amplifier	5	2				
Ranging Unit	7	1				
SHF RF Assembly Group						81
S-Band NB PM RCUR	20	1			1	20
S-Band WB FM RCUR	20	1			1	25
KU Exciter MODEM	6	6			6	36
Low Gain Antenna Group						
VHF Antenna Element	15	3				
VHF Diplexer	3	3				
VHF Multiplexer	6	2				
S-Band Antenna	2	3				
S-Band Triplex Switch	3	1				
VHF/S-Band Coax	8	6				
High Gain Antenna						546
Reflector and Feed	31	3			3	93
Position and Service Control	30	3			3	90
Thermal Control	10	3			3	30
KU Power Amplifier	10	6			6	60
KU Exciter	3	6			6	18
KU Low Noise RCUR	5	6			6	30
S-Band Track RCUR	5	6			6	30
Microwave Network	10	3			3	30
Miscellaneous	15	3			3	45
Mast	40	3			3	120
Internal Communications						172
Int Comm Assembly						172
Audio Terminals	4	18			9	162
Analog Synchronize Test	5	2			2	10
Miscellaneous						8
Attaching Parts						8
Spares				TBD		
10. 06 Communications					807 (366 kg)	

Table 7-39
COMMUNICATIONS (10.06) DETAIL WEIGHTS FOR GPL

	Unit Weight	Total ISS Req	*Logistic Options* Quantity	*Logistic Options* Total Weight	Initial Launch Quantity	Initial Launch Total Weight
RF Communication						
VHF/RF Assembly Group						
Voice XMTR/RCUR	12	2				
Data XMTR/RCUR	10	2				
EVA XMTR/RCUR	2	3				
EVA T/R MODEM	10	1				
S-Band RF Assembly Group						
PM Transponder	23	2				
RM Exciter	3	1				
Power Amplifier	5	2				
Ranging Unit	7	1				
SHF RF Assembly Group						
S-Band NB PM RCUR	20	1				
S-Band WB FM RCUR	25	1				
KU Exciter MODEM	6	6				
Low Gain Antenna Group						
VHF Antenna Element	15	3				
VHF Diplexer	3	3				
VHF Multiplexer	6	2				
S-Band Antenna	2	3				
S-Band Triplex Switch	3	1				
VHF/S-Band Coax	8	6				
High Gain Antenna						
Reflector and Feed	31	3				
Position and Service Control	30	3				
Thermal Control	10	3				
KU Power Amplifier	10	6				
KU Exciter	3	6				
KU Low Noise RCUR	5	6				
S-Band Track RCUR	5	6				
Microwave Network	10	3				
Miscellaneous	15	3				
Mast	40	3				
Internal Communications						108
Int Comm Assembly Group						108
Audio Terminals	4	18			6	108
Analog Synchronize Test	5	2			-	-
Miscellaneous						1
Attaching Parts						1
Spares				TBD		
10.06 Communications - GPL						109 (49 kg)

the GPL module providing experiment program management, and if required, a backup to the primary command and control center (Figure 7-15). Portable display and control units, remote experiment support display and control equipment, and remote intercommunication, alert, and recreation equipment are also provided within these consoles.

The weight data used were taken from several sources, including potential subcontractors, previous programs, and extrapolated data. In all cases, a conservative value was selected to allow for lack of detail definition.

The Portable Monitor and Control Units are used at remote locations where display and control data are required on a part-time basis. The units are also used to assist in onboard checkout, fault isolation, manual backup at docking ports, and experiment equipment calibration and adjustment. A potential subcontractor estimated the weights to be 100 lb each. One unit is on the initial power module launch with the additional units being supplied as logistic options.

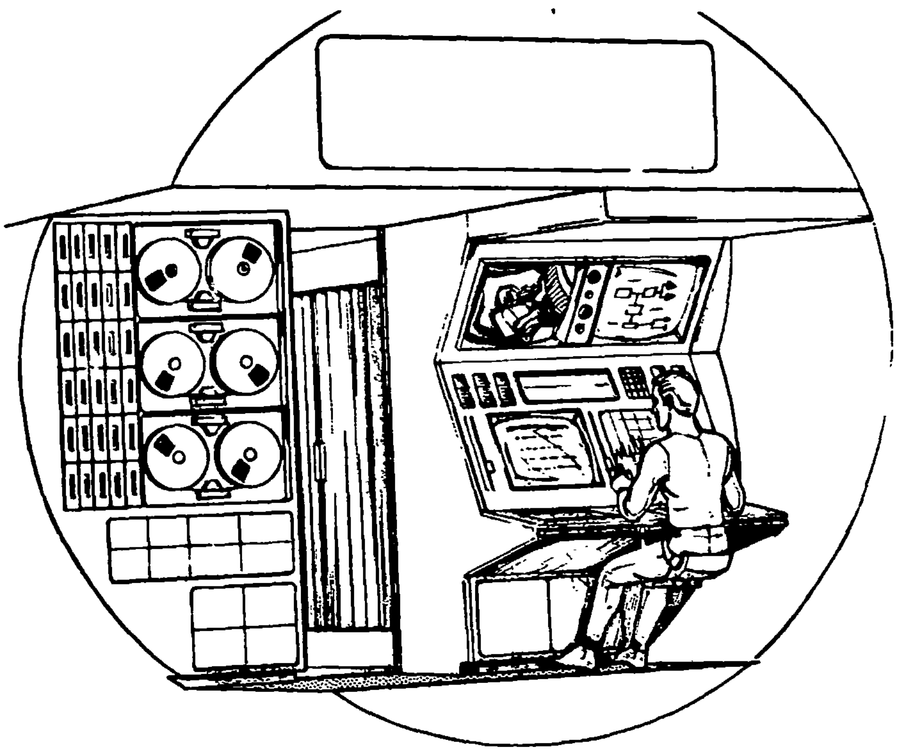
The panels to support the controls are basically in the primary and secondary command control centers. Additional panels are located on stowage and cabinets, and their weights are carried as part of these assemblies. The unit weights for panels was developed on MOL (0.52 lb/ft^2) plus 17 percent for tie-downs, hinges, etc. The total panel area is estimated at 80 ft^2 for the crew module and 120 ft^2 for the GPL.

Tables 7-40 through 7-42 provide a detailed weight summary for the display and control system.

7.13 WIRING (FC 11.00)

The wiring functional code includes all wiring within the station. The methods available for determining wire weight vary with the level of subsystem definition, location, and requirements. The ideal approach is to weigh each wire, connector, and support. The next best method is to calculate each item,

R275



DISPLAYS

- MULTIFORMAT CRT
- VIDEO MONITOR
- MICROFILM VIEWER
- CAUTION-WARNING-EXPERIMENT ALERT
- CONTINUOUS-SOFTWARE CONTROL
- DEDICATED

CONTROLS

- KEYBOARDS
- MICROFILM SELECTION
- HAND CONTROLLER
- CHECKOUT UNIQUE
- SUBSYSTEM DEDICATED
- ANALOG SLEWING

AURAL CUES

- CAUTION AND WARNING
- VOICE MESSAGE GENERATOR

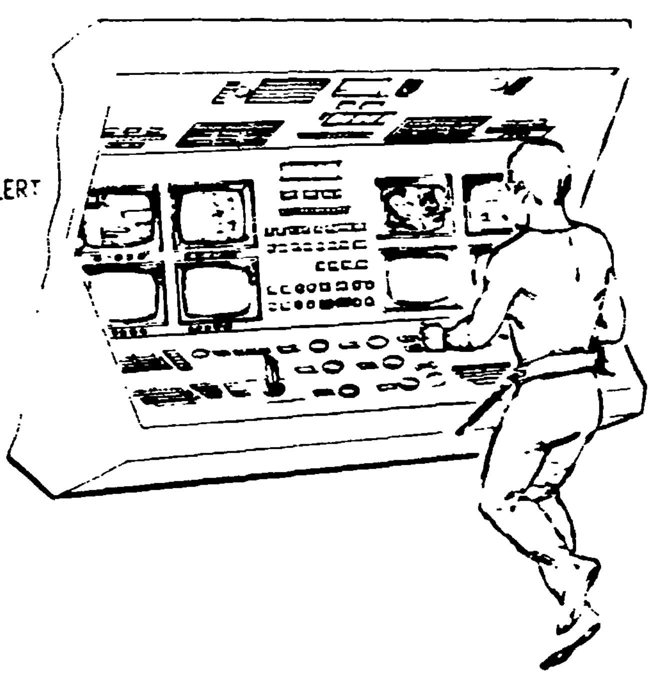


Figure 7-15. Primary and Experiment/Secondary Control Center

Table 7-40

DISPLAY AND CONTROL DETAIL WEIGHT SUMMARY FOR THE POWER MODULE

	Unit Weight	Total ISS Req	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight
Panels						--
Controls						100
Subsystem Console						--
Display Processor	60	2				
Buffer Memory	40	2				
Character Generator	100	2				
D/A Converter	28	2				
Crt and Defcte' Ckt	50	2				
Keyboard	25	2				
Microfilm Viewer	60	1				
Warning Matrix	20	1				
Caution Array	20	1				
Hand Controller	20	1				
Video Monitor	35	1				
Dedicated D and C	75	1				
Experiment Console						--
Display Processor	60	2				
Buffer Memory	40	2				
Character Generator	100	2				
D/A Converter	28	2				
Crt and Defcte Ckt	50	2				
Keyboard	25	2				
Microfilm Viewer	60	2				
Warning Matrix	20	1				
Caution Array	20	1				
Hand Controller	20	2				
Video Monitor	35	4				
Dedicated D and C	75	1				
Portable Monitor and Control	100	4	1	100	1	100
Miscellaneous						--
Spares						--
10.15 Display and Control				100		100 (45 kg)

Table 7-41

DISPLAY AND CONTROL DETAIL WEIGHT SUMMARY FOR THE CREW MODULE

	Unit Weight	Total ISS Req	Logistic Options: Quantity	Logistic Options: Total Weight	Initial Launch: Quantity	Initial Launch: Total Weight		
Panels						42		
Controls						888		
Subsystem Console							836	
Display Processor	60	2			2			120
Buffer Memory	40	2			2			80
Character Generator	100	2			2			200
D/A Converter	28	2			2			56
Crt and Defcte Ckt	50	2			2			100
Keyboard	25	2			2			50
Microfilm Viewer	60	1			1			60
Warning Matrix	20	1			1			20
Caution Array	20	1			1			20
Hand Controller	20	1			1			20
Video Monitor	35	1			1			35
Dedicated D and C	75	1			1			75
Experiment Console							--	
Display Processor	60	2						--
Buffer Memory	40	2						--
Character Generator	100	2						--
D/A Converter	28	2						--
Crt and Defcte Ckt	50	2						--
Keyboard	25	2						--
Microfilm Viewer	60	2						--
Warning Matrix	20	1						--
Caution Array	20	1						--
Hand Controller	20	2						--
Video Monitor	35	4						--
Dedicated D and C	75	1						--
Portable Monitor and Control	100	4			--		--	
Miscellaneous							52	
Attaching Parts								
Misc 5%							42	
Spares							--	
10.15 Display and Control						930 (422 kg)		

Table 7-42

DISPLAY AND CONTROL DETAIL WEIGHT SUMMARY
FOR THE GPL MODULE

	Unit Weight	Total ISS Req	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight
Panels						62
Controls						913
Subsystem Console						--
Display Processor	60	2				--
Buffer Memory	40	2				--
Character Generator	100	2				--
D/A Converter	28	2				--
Crt and Defcte Ckt	50	2				--
Keyboard	25	2				---
Microfilm Viewer	60	1				--
Warning Matrix	20	1				--
Caution Array	20	1				--
Hand Controller	20	1				--
Video Monitor	35	1				--
Dedicated D and C	75	1				--
Experiment Console						861
Display Processor	60	2				120
Buffer Memory	40	2				80
Character Generator	100	2				200
D/A Converter	28	2				56
Crt and Defcte Ckt	50	2				100
Keyboard	25	2				50
Microfilm Viewer	60	2	2	120		--
Warning Matrix	20	1				20
Caution Array	20	1				20
Hand Controller	20	2	2	40		--
Video Monitor	35	4				140
Dedicated D and C	75	1				75
Portable Monitor and Control	100	4	2	200	--	--
Miscellaneous	--	--	--	--		52
Attaching Parts						9
Misc						43
Spares				TBD		
10.15 Display and Controls				360		975 (442 kg)

using production drawings, the next method consists of estimates based on layouts and detail subsystem definition, and the final method is to estimate the weights on the basis of previous experience on existing programs or past studies. Current subsystem definition, coupled with time limits, permitted only the later approach to be used.

Using data from the MOL program, it was established that wire weight was equal to 60 percent of the weight of the components they connected, using conventional 24-gage round wire. The Space Station in a data bus concept is estimated to reduce the weight of the wiring assemblies over conventional techniques by 22 percent. A further weight-reduction technique was selected where a portion of the conventional round wire was replaced with flat cable where applicable, reducing the weight by an additional 25 percent, which results in a wire weight equal to 35.1 percent of the associated component weight. Some of the round wire remaining on the station can be 26 or 28 gage where acceptable, further reducing the weight; but this difference was left in the listed weights to allow for the lack of detail definition at this time. The wire supports and connectors were estimated from similar data developed on the MOL Program. Table 7-43 presents the weight details for the wiring hardness assemblies and support provisions and Figure 7-16 the typical wiring concept.

Table 7-43
WIRING WEIGHT FOR SPACE STATION MODULES

	Modules		
	Power	Crew	GPL
Guidance and Control	78	20	0
Onboard Checkout	138	136	118
Data Management	97	113	409
Communication	107	92	38
Display and Controls	---	312	327
Power Distribution	107	49	46
Contingency	53	72	94
11.00 Wiring	580 (263 kg)	794 (360 kg)	1,032 (468 kg)

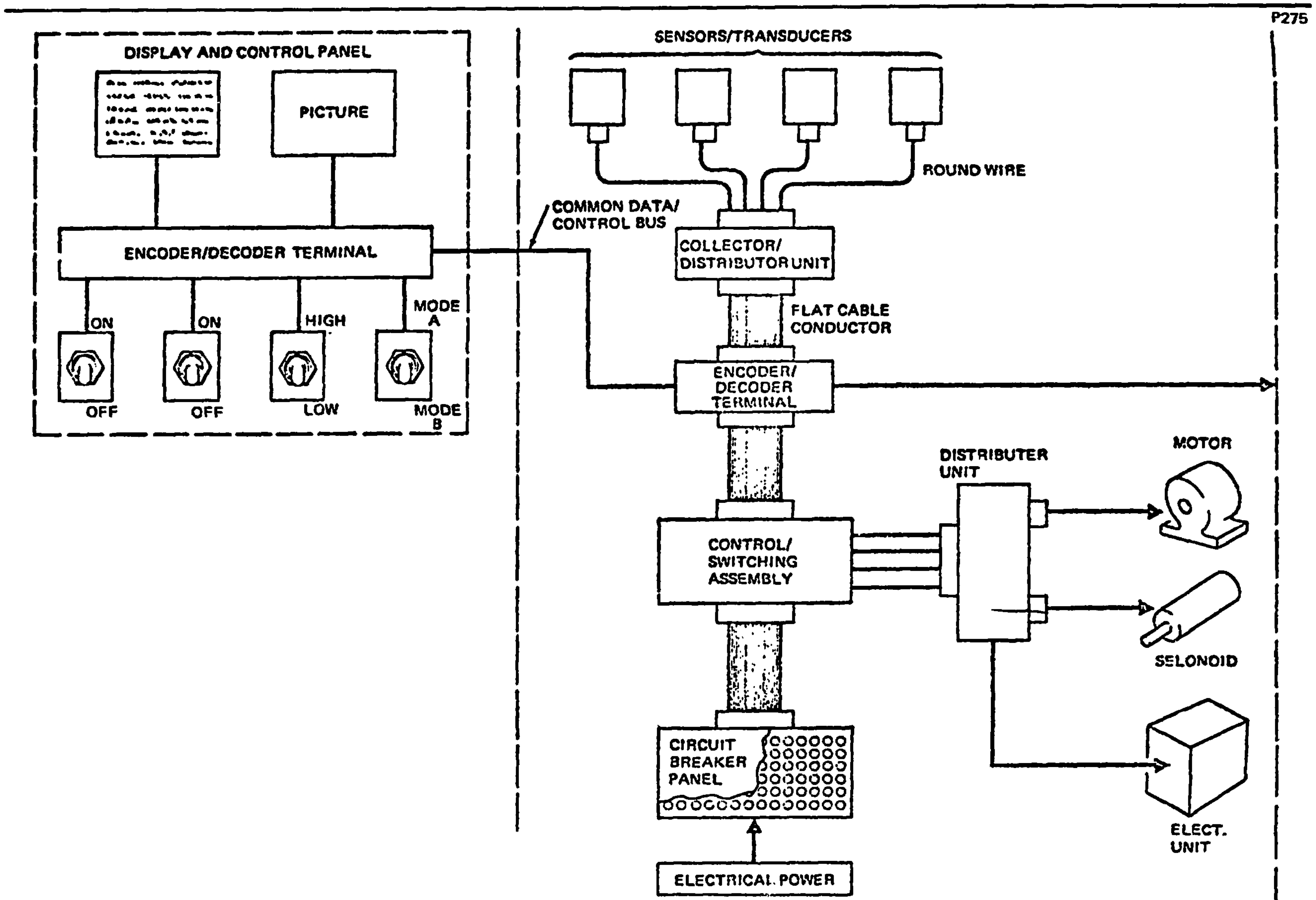


Figure 7-16. Typical Wiring Concept

7.14 ATMOSPHERE AND THERMAL CONTROL (FC 12.00)

The Atmosphere and Thermal Control system provides cabin atmosphere control and purification, pressure suit support, and thermal control for the entire Space Station. Concepts selected are listed in Table 7-44.

The cabin atmosphere is maintained at sea level pressure and two six-man atmosphere reconditioning subsystems are provided, one in the crew module and one in the GPL. The crew module unit processes gas for the crew, power and attached modules. Each module contains separate atmosphere cooling provisions. Each unit is capable of processing the entire station atmosphere including attached modules. Normally the unit in the Crew Operations Module will process all atmosphere except the GPL which will provide its own processing. In a contingency, either unit will process the total atmosphere. Each module contains separate atmosphere cooling provisions.

The ISS employs an open oxygen loop initially but provisions are included to add oxygen recovery at any time. CO_2 removed from the atmosphere by molecular sieves is used in a resistojet low thrust propulsion system.

The total heat generated in the Space Station is rejected to space through segmented radiators integrated with the micrometeoroid shield. Each core module contains independent thermal control loops. A separate water loop between core compartments provides a sharing of cooling capacity. A solar collector is mounted on the solar array structure to provide for EC/LS process heat.

A total mass balance for the EC/LS subsystem is shown in Figure 7-17. Inputs are food, water contained in the food, and gaseous oxygen makeup. Outputs are fecal water, miscellaneous solids associated with the metabolic process, non-recoverable water from urine purification, carbon dioxide utilized by the propulsion subsystem, and a water surplus, part of which is used for EVA cooling. With the exception of the CO_2 used as propellant, and the leakage gases, no products from the EC/LS are dumped or vented overboard.

Table 7-44

ATMOSPHERE AND THERMAL CONTROL
FUNCTIONS AND CONCEPTS

Function	Concept
O_2 and N_2 storage	Gaseous at 3,000 psia
Atmosphere temperature control	Module heat exchangers
Humidity control	Condenser-separators
Trace contaminant control	Catalytic oxidation
CO_2 rmoval	CO_2 save molecular sieve
Ventilation	Central fan-diffusers
EVA/IVA	PLSS/PLSS or face mask
Thermal control	Two fluid circuits and integral radiator
Process heat	Solar collection

Figures 7-18, 7-19, and 7-20 are assembly-level schematics of the EC/LS subsystem which show how the assemblies are interrelated and how the subsystem is integrated within the 3-core modules. If the EC/LS is inoperative in either compartment, the remaining unit can accommodate the entire ISS through the interconnecting ducting. However, the two habitable volumes are processed separately although some intermixing will occur.

A 96-hour pallet is provided which contains all essential EC/LS services, food or emergency power for the Crew. (Figure 7-21) This assembly does not rely on any onboard system for support and is self contained for ease of location and movement throughout the Space Station. The pallet contains the following provisions: (1) oxygen, (2) water for crew intake and cooling, (3) food, (4) LiOH for CO_2 control, (5) a water boiler, and (6) miscellaneous medical and personal hygiene provisions. Two of these three-man pallets

R275

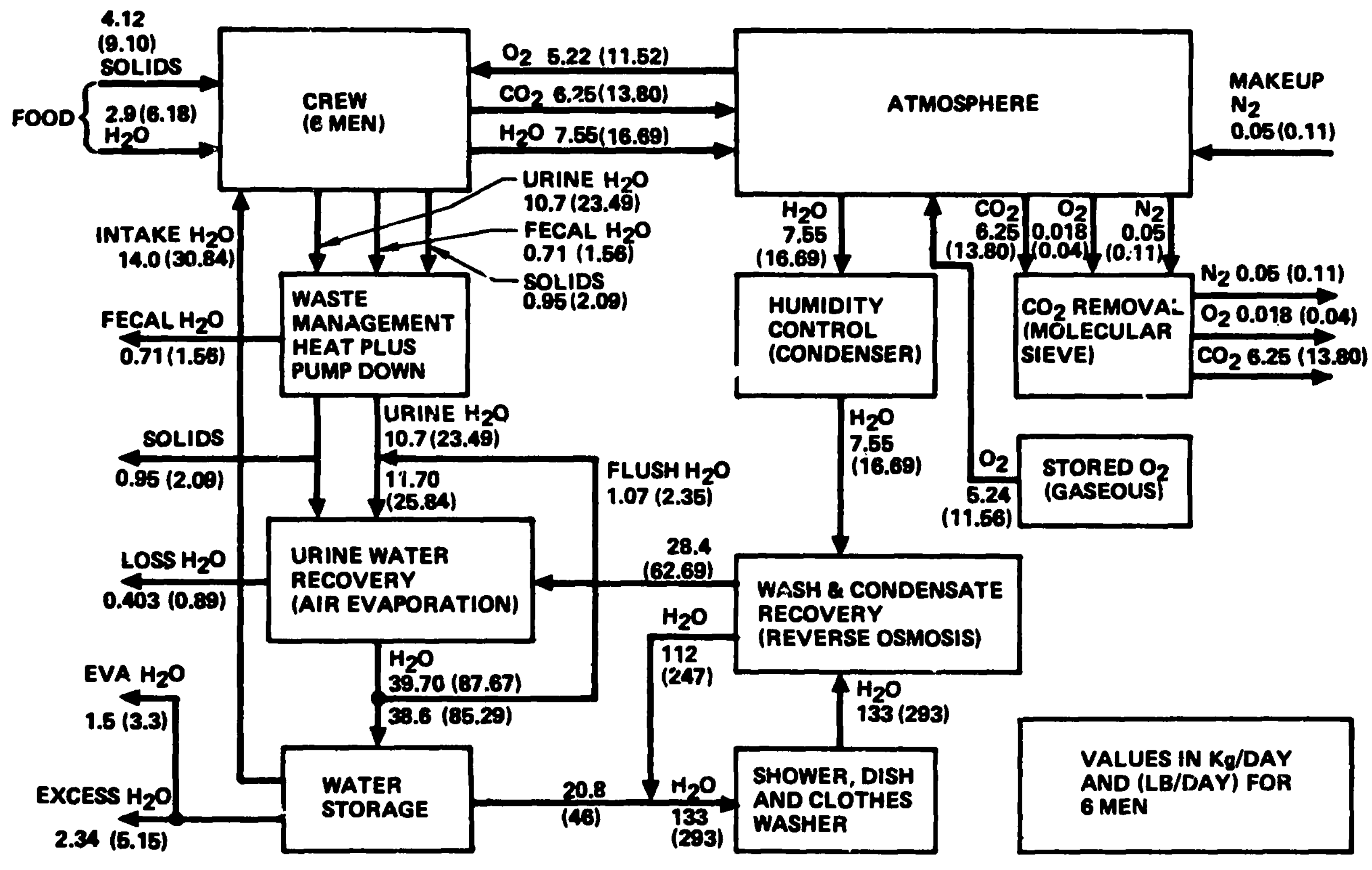


Figure 7–17. Environmental Control and Crew Support Mass Balance

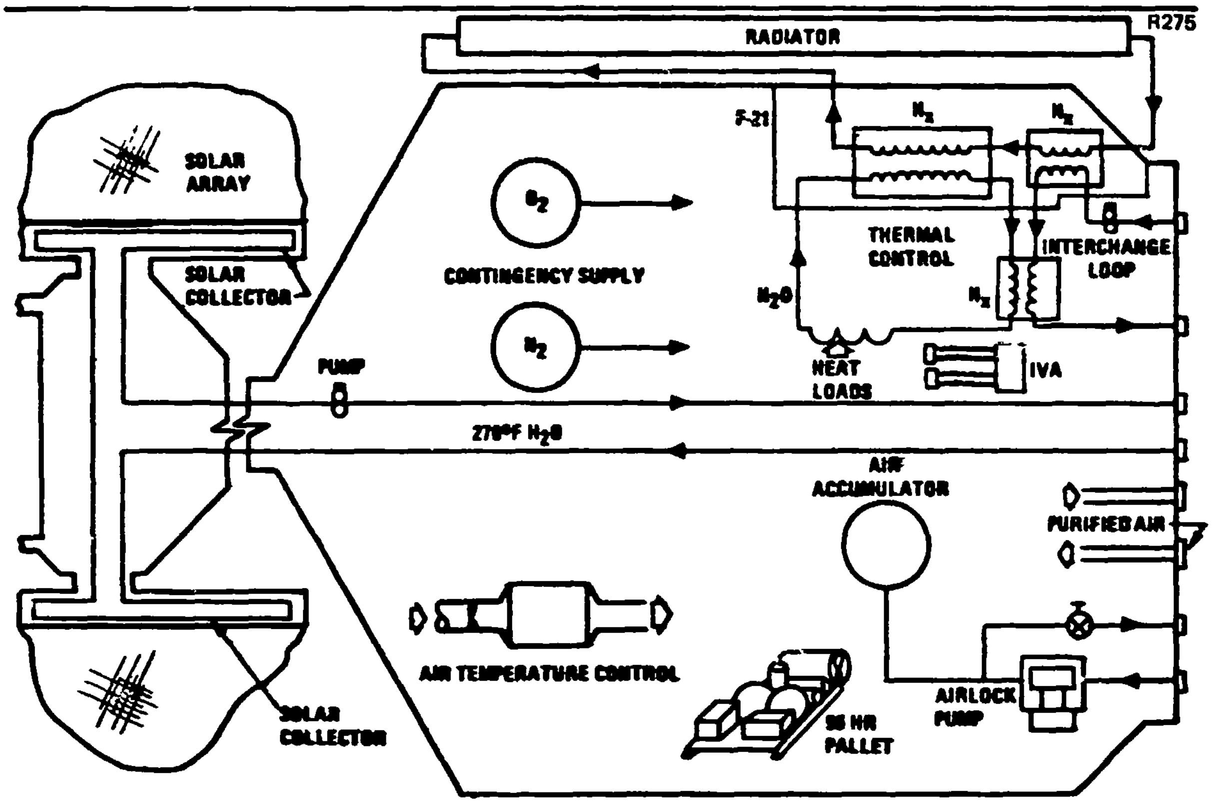


Figure 7-18. Power Module EC/LS Schematic

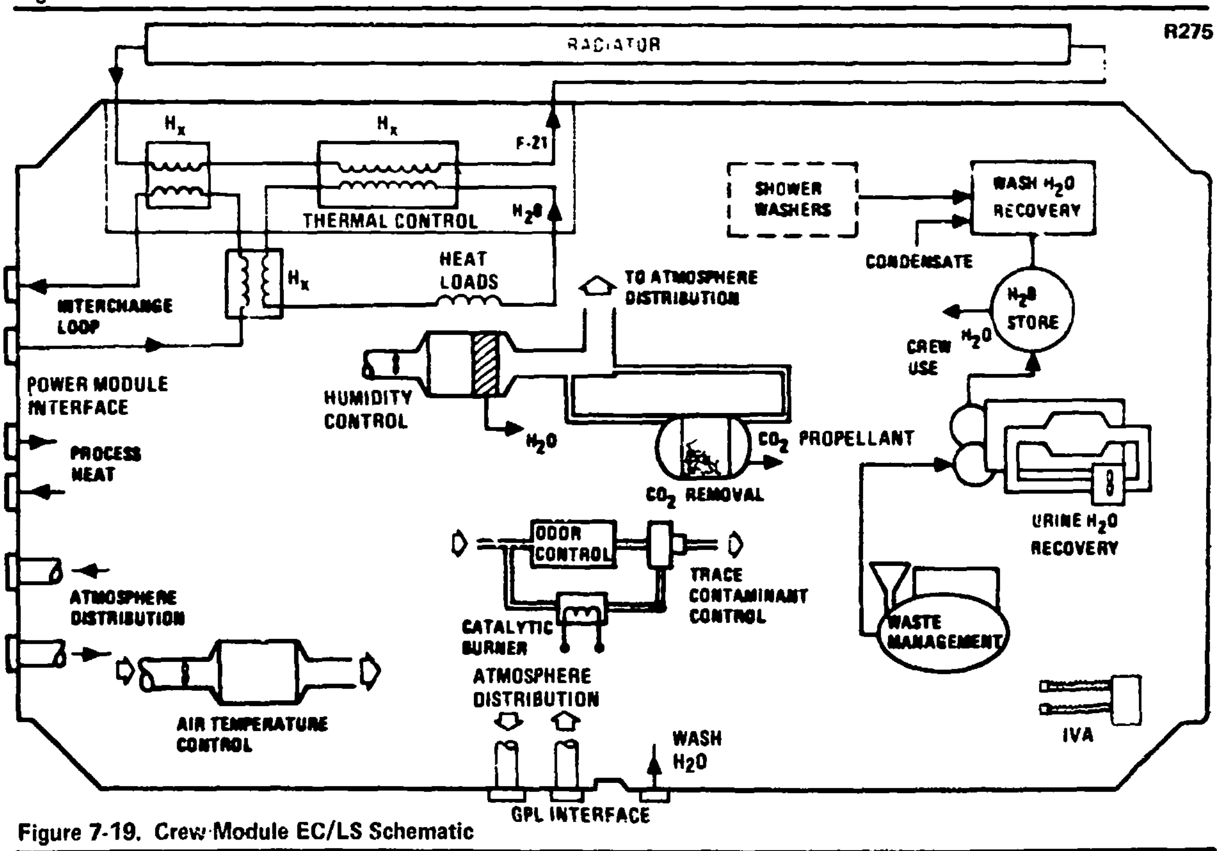


Figure 7-19. Crew Module EC/LS Schematic

R275

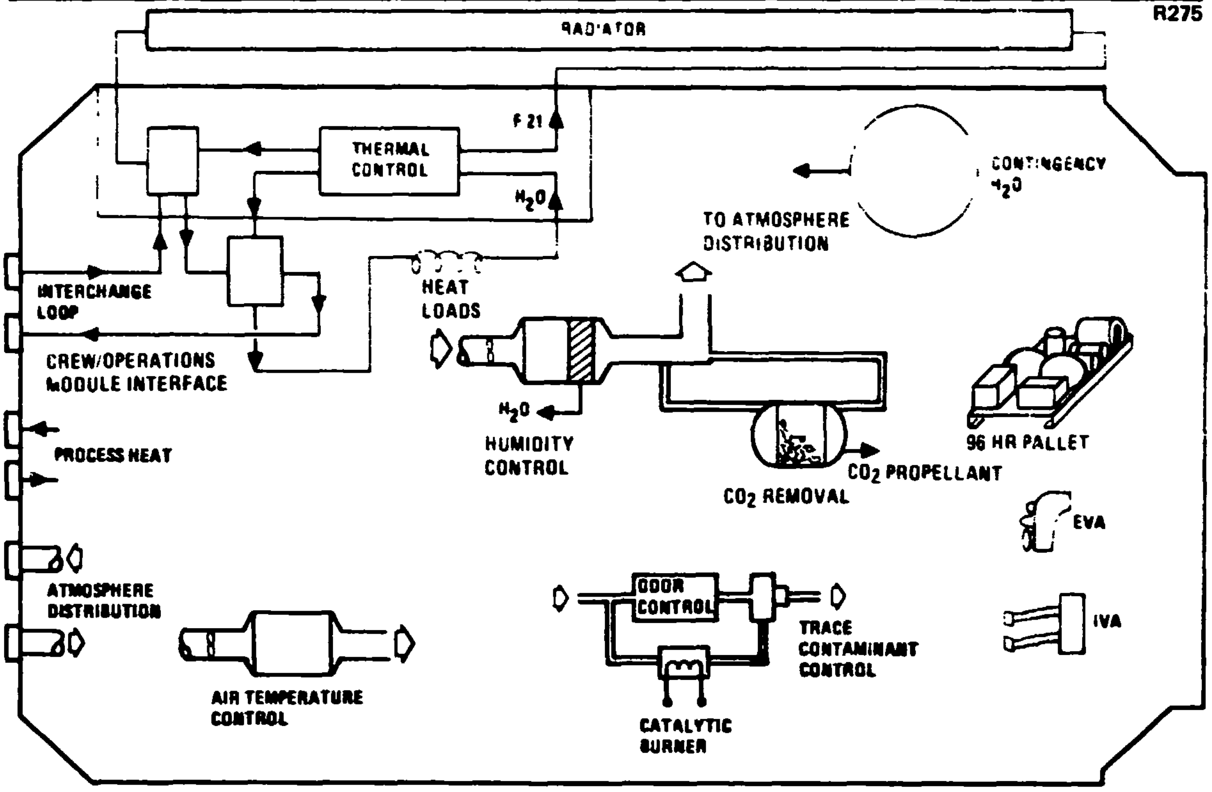
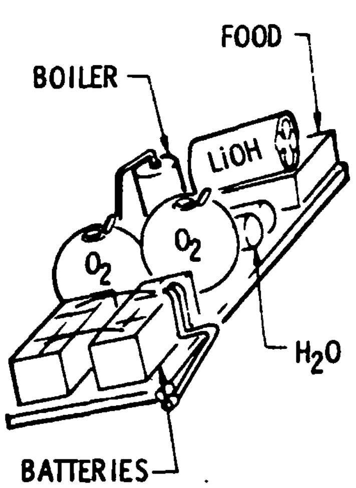


Figure 7-20. GPL Module EC/LS Schematic

R275



3-MAN PALLET

PROVISION	REQUIREMENT	WEIGHT KG (LB)
OXYGEN	METABOLIC O_2	23.6 (52)
WATER	CREW INTAKE PLUS COOLING	64.4 (142)
FOOD	2700 K CAL DIET	13.6 (30)
LiOH	MAINTAIN 0.102 KN/M^2 (7.6 mm Hg) PCO_2	19.0 (42)
BATTERIES	960 WATT-HR	22.6 (50)
WATER BOILER	740 WATT (1600 BTU/HR) COOLING	3.2 (7)
MISCELLANEOUS SUPPLIES		2.3 (5)
PALLET/PACKAGING		11.3 (25)
	TOTAL	160.0 (353)

Figure 7-21. 96-Hour Emergency Pallet

are normally located in the GPL and one pallet is located in each attached module. During buildup, a pallet could be located in the power module prior to its launch if added crew backup is desired.

Atmosphere and thermal control parameters are listed in Table 7-45. A detailed weight summary for the atmosphere and thermal control system is contained in Tables 7-46 through 7-48.

7.15 CREW LIFE SUPPORT AND FURNISHINGS (FC 14.00)

This functional code includes crew restraints, handrails, water management, personal hygiene, galley equipment, food stowage, housekeeping, trash management, cargo handling, and furnishings.

The Restraints and Handrails include pelvis, lower leg, foot, loose sleep, tether restraints, and handrails. Stowage and consoles have their own built-in restraints and handrails, which are summarized with these items. Interior layout drawings were used to determine handrail lengths and the unit weights are those used on OWS, which include support allowances (0.34 lb/ft^3). The weights for restraints are those developed for MOL and OWS.

The crew life support provisions are composed of the hygiene facility, water management, galley, housekeeping provisions, and trash management.

The hygiene facilities permits use by four crewmen at a time. Each facility (Figure 7-22) includes a commode composed of a fecal and urinal collector, a shower, a clothes washer/dryer, a separate urinal, a camber sink, and the associated stowage for common and personal hygiene equipment. The shower and camber sinks use both blowers and towel wipes for drying.

The urinals and fecal collector weights are supplied by Fairchild Hiller along with usage rates for expendables. Shower and camber sink weights were derived from vendor catalogs. The washer/dryer weight was estimated from a commercial unit with the shell removed, and allowance was made for lighter materials.

Table 7-45

ATMOSPHERE AND THERMAL CONTROL PARAMETERS

<u>Atmosphere Supply and Control</u>	
Depressurizable Compartment Volume	23.2 m^3—440 m^3/30 days
Depressurizable Compartment Time, Minimum	24 hrs for 115 m^3 (4078 cu ft)
Repressurization/Contingency Supply	Onboard storage for one repressurization of largest compartment
Repressurization Time	6 hours maximum
Leakage	Negligible
Atmosphere Relief	Relieves cabin pressure at 105.5 + 1.4 KN/m^2 (15 + 0.2 psia) Dump largest compartment to 6.89 KN/m^2 (1 psia) or less in 3 minutes.
Atmosphere	
Oxygen Partial Pressure	21.4 KN/m^2 (3.1 psia)
Total Pressure	101 KN/m^2 (14.7 psia)
<u>Atmosphere Reconditioning</u>	
CO_2 Partial Pressure	Normal—0.4 KN/m^2 (3 mm Hg) or less Emergency—1.0 KN/m^2 (7.6 mm Hg) maximum for 7 days.
CO_2 Generation Rate, Peak/Average	0.354/0.260 Kg/hr (0.78/0.575 lb/hr) (6 men)
O_2 Use Rate, Average	0.218 Kg/hr (0.48 lb/hr) (6 men)
Trace Contaminants	Same as Phase B SS Study
Free Moisture in atmosphere	None allowed
Particulate filtration level	Class 100,000 clean room
Atmosphere heat load	Crew metabolic +20% of net electrical power output

Table 7-45

ATMOSPHERE AND THERMAL CONTROL PARAMETERS (Continued)

Atmosphere Reconditioning (Cont)	
Metabolic levels	Normal—136 watts (465 Btu/hr) for 24 hr Design—2 men at 235 w (800 Btu/hr) 4 men at 161 w (550 Btu/hr)
Atmosphere Temperature	18.4 - 23.9°C (65 - 85°F) selectable
Dewpoint Temperature	7.2 - 14.5°C (45 - 85°F) with transients to 4.5°C (40°F) allowable
Mean Radiant Wall Temperature	18.4 - 23.9°C (65 - 85°F)
Velocity in Occupied Regions	0.1 - 0.25 m/sec (20-50 ft per min)
Design latent load	
Crew	640 w (2180 Btu/hr)
Crew Equipment	385 w (1313 Btu/hr)
Experiments	306 w (1042 Btu/hr)
<u>EVA/IVA</u>	
EVA metabolic rate, peak	586 w (2000 Btu/hr) 2 hr
EVA metabolic rate, average	352 w (1200 Btu/hr) 4 hr
IVA metabolic rate, peak	470 w (1600 Btu/hr) 2 hr
IVA metabolic rate, average	234 w (800 Btu/hr) 4 hr
Preconditioning time per suited event	6 to 8 hr
Suit pressure	25.5 KN/m^2 (3.7 psia)
Average number of EVA activities	1.5 events/month
Number of crewmen	2 crewmen/event

Table 7-45

ATMOSHPERE AND THERMAL CONTROL PARAMETERS (Continued)

Thermal Control	
Orbit Inclination	55°
Orbit Altitude	444 to 500 km (240 to 270 nmi)
Orientation	No restrictions allowed
Heat Leaks	Minimize
Structural Interface	Integrated meteoroid shield/radiator
Radiator Reliability	0.99 for each module for 10 yr

The water management subsystem has full H_2O recovery using reverse osmosis. The waste management subsystem is located in the Crew Module, with a 30-day contingency water supply located in the GPL. The provisions include urine water recovery, wash water condensate recovery, water stowage, and portable monitoring. The weights were supplied by Hamilton Standard.

Food management is composed of an oven, a diswasher, utensils, food and food stowage. The microwave ovens include an infrared heater to provide familiar color and appearance to cooked items. The weights were obtained from Fairchild Hiller. Each oven has food preparation capability for 6 man-meals. The second oven provides redundancy and permits simultaneous heating of different foods at different temperatures.

The two dishwasher/dryers will be capable of cleaning the utensils used for a six-man meal. The weights were derived from a commercial unit (63 lb).

E ting and preparation utensils are supplied for nine-man meals and are reusable. With the use of the microwave oven, fiberglass-reinforced

Table 7-46

ATMOSPHERE AND THERMAL CONTROL DETAIL WEIGHT SUMMARY FOR POWER MODULE

		Unit Weight	Total ISS Req	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight		
12.01	Equipment Thermal Control						183		
	Cold Plates	10	30			11		110	
	Water Thermal Control							42	
	Coolant H_2O Recir	13	3			1			13
	Heated H_2O Recir	12	2			2			24
	Misc 20%	--	--			--			5
	Plumbing 50%	--	--			--		21	
	Attaching Parts	--	--			--		10	
	Spares	--	--		TBD	--		--	
12.02	E. C. Personal						430		
	Atmosphere Supply and Control							200	
	Repressurization O_2	293	1	1	293	--			--
	Repressurization N_2	353	3	3	1,059	--			--
	Metabolic O_2 (Res)	240	3	3	720	--			--
	(1) Metabolic O_2 (Nom)	--	--	--	--	--			--
	Pump Down Accum	42	2	2	84	--			--
	Pressure Reduction	17	2	--	--	2			34
	Pressure Control	18	2	--	--	--			--
	Compartment Repress	2	5	--	--	1			2
	Dump and Relief	15	3	--	--	1			15
	Docking Port Cont	12	10	--	--	4			48
	Airlock Press Cont	5	3	--	--	--			--
	Airlock Pump	50	1	--	--	1			50
	PLSS Recharge	1	1	--	--	1			1
	Makeup Atmosphere	--	--	--	--	--			50
	Atmosphere Reconditioning							97	
	Humidity Control	35	2	--	--	--			--
	Contaminant Control	94	2	--	--	--			--
	CO_2 Removal	551	2	--	--	--			--
	Air Temp Control	42	3	--	--	1			42
	Atmosphere Distrib	43	3	--	--	1			43
	Ventilation	6	2	--	--	2			12
	Contamination Monitor	33	2	--	--	--			--
	Support Provisions							91	
	(2) 96-Hour Pallets	760	3	1	760			42	
	Ducting and Plumbing	--	--	--	--			--	
	Spares	--	--		TBD				
12.03	Radiator Thermal Control						218		
	Radiator Recirculation	10	3	--	--	1		10	
	Radiator Control Assembly	154	3	--	--	1		154	
	Interchange Loop Recir	12	1	--	--	1		12	
	Waste Heat Exchanger	6	1	--	--	-		6	
	Misc 20%							36	
12.00	Atmosphere and TC						831 (374 kg)		

Table 7-47

ATMOSPHERE AND THERMAL CONTROL DETAIL WEIGHT SUMMARY FOR CREW MODULE

		Unit Weight	Total ISS Req	Logistic Options		Initial Launch			
				Quantity	Total Weight	Quantity	Total Weight		
12.01	Equipment Thermal Control						141		
	Cold Plates	10	30	--	--	9		90	
	Water Thermal Control			--	--			15	
	Coolant H_2O Recir	13	3	--	--	1			
	Heated H_2O Recir	12	2	--	--	--			13
	Misc 20%	--	--	--	--	--			2
	Plumbing 50%	--	--	--	--	--		26	
	Attaching Parts	--	--	--	--	--		10	
	Spares	--	--	--	TBD	--		--	
12.02	E.C. Personal						948		
	Atmosphere Supply and Control								
	Repressurization O_2	293	1	--	--	--			--
	Repressurization N_2	353	3	--	--	--			--
	Metabolic O_2 (Res)	240	3	--	--	--			--
	(1) Metabolic O_2 (Nom)	--	--	--	--	--			--
	Pump Down Accum	42	2	--	--	--			--
	Pressure Reduction	17	2	--	--	--			--
	Pressure Control	18	2	--	--	1			18
	Compartment Repress	2	5	--	--	3			6
	Dump and Relief	15	3	--	--	1			15
	Docking Port Cont	12	10	--	--	5			60
	Airlock Press Cont	5	3	--	--	--			--
	Airlock Pump	50	1	--	--	--			--
	PLSS Recharge	1	1	--	--	--			--
	Atmosphere Reconditioning							798	
	Humidity Control	35	2	--	--	1			35
	Contaminant Control	94	2	--	--	1			94
	CO_2 Removal	551	2	--	--	1			551
	Air Temp Control	42	3	--	--	1			42
	Atmosphere Distrib	43	3	--	--	1			43
	Ventilation	6	2	--	--	--			--
	Contaminant Monitor	33	2	--	--	1			33
	(2) 96-Hour Pallets	760	3	2	1,520	--		--	
	Ducting and Plumbing	--	--		--			51	
	Spares	--	--		TBD				
12.03	Radiator Thermal Control			--	--		197		
	Radiator Recirculation	10	3			1		10	
	Radiator Control Assembly	154	3	--	--	1		154	
	Interchange Loop Recir	12	1	--	--	--		--	
	Waste Heat Exchanger	6	1	--	--	--		--	
	Misc 20%							33	
	Atmosphere and TC				1,520		1,287 (583 kg)		

(1) Remains in logistic module (pantry concept).

Table 7-48

ATMOSPHERE AND THERMAL CONTROL DETAIL WEIGHT SUMMARY FOR GPL MODULE

		Unit Weight	Total ISS Req	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight		
12 01	Equipment Thermal Control						151		
	Cold Plates	10	30	--	--	10		100	
	Water Thermal Control			--	--			15	
	Coolant H_2O Recir	13	3	--	--	1			13
	Heated H_2O Recir	6	2	--	--	--			--
	Misc 20%								2
	Plumbing 50%	--	--					26	
	Attaching Parts	--	--	--	--	--		10	
	Spares	--	--		TBD	--		--	
12. 02	E. C. Personal						911		
	Atmosphere Supply and Control							62	
	Repressurization O_2	293	1	--	--				--
	Repressurization N_2	353	3	--	--				--
	Metabolic O_2 (Res)	240	3	--	--				--
	(1) Metabolic O_2 (Nom)	--	--	--	--	--			--
	Pump Down Accum	42	2	--	--	--			--
	Pressure Reduction	17	2	--	--	--			--
	Pressure Control	18	2	--	--	1			18
	Compartment Repress	2	5	--	--	1			2
	Dump and Relief	15	3	--	--	1			15
	Docking Port Cont	12	10	--	--	1			12
	Airlock Press Cont	5	3	--	--	3			15
	Airlock Pump	50	1	--	--	--			--
	PLSS Recharge	1	1	--	--	--			--
	Atmosphere Reconditioning							798	
	Humidity Control	35	2	--	--	1			35
	Contaminant Control	94	2	--	--	1			94
	CO_2 Removal	551	2	--	--	1			551
	Air Temp Control	42	3	--	--	1			42
	Atmosphere Distrib	43	3	--	--	1			43
	Ventilation	6	2	--	--	1			--
	Contaminant Monitor	33	2	--	--	1			33
	(2) 96 Hour Pallets	760	3	--	--	--		--	--
	Ducting and Plumbing	--	--	--	--	--		51	
	Spares	--	--	--	TBD	--		--	
12. 03	Radiator Thermal Control						197		
	Radiator Recirculation	10	3			1		10	
	Radiator Control Assembly	154	3			1		154	
	Interchange Loop Recir	12	1			--		--	
	Waste Heat Exchanger	6	1			--		--	
	Misc 20%							33	
	Atmosphere and TC						1, 259 (571 kg)		

(1) Remains in logistic module (pantry concept).

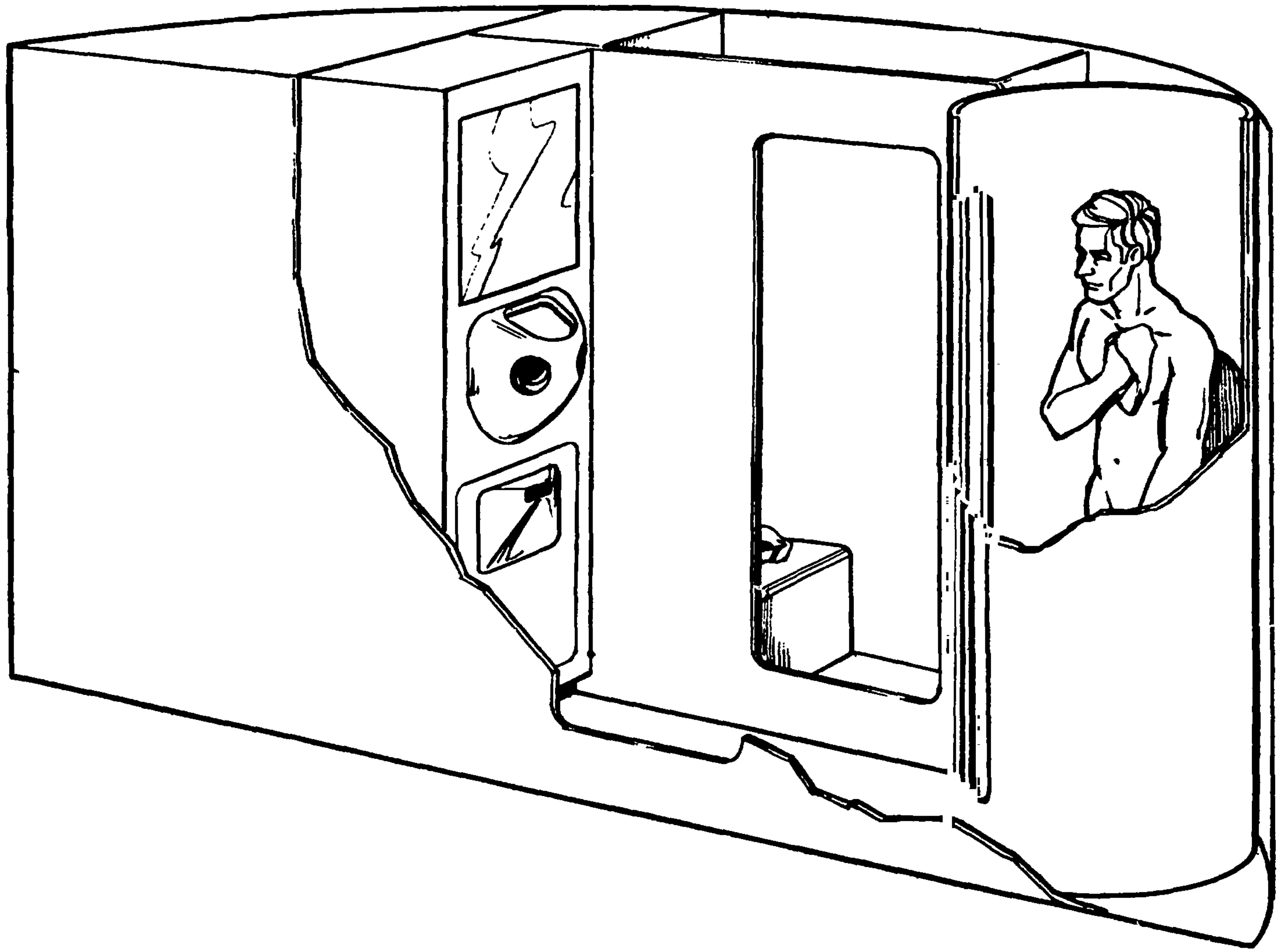


Figure 7-22. Hygiene Facility—Crew/Operations Module

polymide utensils will be used to permit energy transmission. Weights were taken from existing houseware when possible, and density-to-volume ratios were used for the remaining items.

The Station food provides a daily consumption of 2,800 K cal per man to meet the demands of metabolic requirements. The food stowage includes refrigerators, freezers, and ambient dry cabinets.

The food is located in the galley with supplies for 180 man-days plus a second 180 man-days for contingency backup in the GPL. The food is an advanced OWS development.

The food stowage was sized to contain the food noted (Table 7-49) and is of three basic types of food stowage: freezer, refrigerator/chiller, and dry stowage.

The food freezer is sized to contain 182 lb of frozen food at an average density of 52 lb/ft^3. By assuming a 10-percent volume margin and two freezers, a net volume of 3.9 ft^3 per unit is required, or an envelope of approximately 1.0 by 1.5 by 2.5 ft. For determining weights, both the inner and outer walls were estimated to be 0.050-in.-thick aluminum sheet with a fiberglass liner. The insulation selected is the same as the external meteoroid and radiator shroud (0.19 lb/ft^2 for 48 layers). The weight for distribution, electrical controls, fluid, and lines was assumed to equal the same percent of the total assembly as that derived from OWS (24.5 percent). The refrigerator/chillers are similar to the freezer in design, with the possibility of reducing insulation and coolant provisions. This would be offset by the increase in thermal controls; for weight estimates, therefore, the unit weight (2.6 lb/ft^2) was assumed to be the same as that of the freezer. The food volume plus a 10-percent volume margin is 3.3 ft^3 per unit. Envelope dimensions are approximately the same as the freeze unit.

The dry food stowage was estimated on total volume plus the 10-percent margin for a 1-by 2- by 3-ft module (two required) using a unit weight of

Table 7-49

FOOD WEIGHTS FOR 180 MAN-DAYS

Type of Food	Usage Rate (lb/man-day)	Total Food Weight* (lb)	Average Density (lb/ft3)	Internal Volume (ft^3)			
				Freezer	Refrig-erator/Chiller	Dry	Tota
Wet rack	0.76	137	54.7	--	1.0	1.5	2.5
rozen	1.00	182	52.0	3.5			3.5
Dehydrated	0.45	82	49.0	--	--	1.7	1.7
Freeze-dried	0.45	82	10.0	--	--	8.2	8.2
Perishable	0.26	46	23.2	--	2.0	--	2.0
Totals	2.92	529		3.5	3.0	11.4	17.9

*Includes packaging allowance.

1.25 lb/ft^2. The unit weight is a single-wall design with an internal liner and a 12-percent nonoptimum factor for hinges, lights, attachments, etc.

The support structure was estimated at 1 percent of the total food and stowage weight based on OWS values.

The housekeeping and trash management system collects and contains all waste in the station to await return to earth. It also reduces the volume of trash and deactivates bacteria in trash.

The housekeeping equipment includes four vacuum cleaners, disposable vacuum cleaner and collection bags, retriever nets, and a variety of wipes. The trash management facility includes a vacuum dryer, collection liner bags, a compactor, and cannisters. Trash receptacles with bag liners will be located throughout the station to collect waste products. When filled, the pre-treated trash bags will be processed by the vacuum dryer, which removes 99.5 percent of the moisture to eliminate bacteria growth. The processor has three compartments to accommodate various bag sizes. An overboard dump system vents water vapor and gases generated by the processor. The trash compactor consists of a hydraulic assembly and piston, loading camber, and interchangeable trash cargo cannisters. The piston is capable of exerting a force of 2,000 lb to reduce trash to 25 percent of its original volume (288 ft^3 x 0.25 = 72 ft^3). A backup method of deactivating the bacteria in the trash can be provided in case the trash processor fails. Uncompacted trash will be collected in empty stowage containers and only a bag liner will be added to permit sealing. The compacted trash cannister will be supplied on logistic launch and placed aboard the Log-M when filled.

Each cannister was sized to contain 2.7 ft^3 in a 22-in.-diameter cylinder, with a cylindrical section length of 11 in. The cannister will not have to react to any differential pressure; therefore 0.050-gage-material was selected for minimum handling. A 30-percent nonoptimum was added for seals, lands, bosses, handles, etc.

The total quantity of cannisters required at 2.7 ft^3 per unit is approximately 12, of which 3 are for experiments. Bag liner weights were estimated, using 2-mil-thick polyimide material. The bag liners are inserted in the waste receptacles located throughout the station. The cannister housing is part of stowage and not a separate item.

Cargo handling comprises miscellaneous rail transports. Devices located near each docking port. The furnishings include such items as partitions, doors, stowage, benches, lights, and finishes. Figures 3-1 through 3-3 illustrate the general arrangement and features.

From layouts similar to those noted, it was estimated that there are 744 ft^2 of wall area in the Crew Module. The weights were estimated, using 3/4-in. aluminum honeycomb (P = 2.0 lb. ft^3) with two 7075-T73 facing sheets (0.010 in.) and a thermal setting resin (0.5 lb/ft^2/layer). Nonoptimums are 5 percent for the skin, 10 percent for bond and core, and 20 percent for the Z closure channels. In addition, 15 percent was added to the total to account for track attachment. The net unit weight used is 0.77 lb/ft^2. The doors are a curtain-type door made of Beta cloth.

Volumes of the stowage cabinets and consoles are calculated from current interior arrangements. Current estimates of stowage requirements show this to be in excess of actual needs. The excess volume was left to account for lack of detail requirements. The unit weights were obtained from MOL for panel weights, and internal shelving and supports are based on OWS. The total value of 0.867 lb/ft^2 was applied to the total surface area plus the divided spacerarea. It is estimated that less than 15 percent of the envelope volume will be lost to structure and dividers. Using this factor, a total of 428 ft^3 of usable stowage space is available for station in the Crew Module and 256 ft^3 in the GPL Module.

Furnishings include desks and bunks in the crew quarters. The desk weights were estimated in the same manner as the cabinets and consoles. The fluorescent type lighting system weights were derived from a study that Sylvania performed. The material selected for wall finishing is a nonspecular paint applied over the total interior of each module.

The design specifications are noted in Table 7-50 with the detailed weights summarized in Table 7-51 through 7-53.

7.16 CREW EQUIPMENT (FC 17.00)

Crew equipment includes personal gear, medical provisions, recreation and exercise equipment, hand tools, and fire extinguishers. The weights for these items were derived from MOL, OWS, and extrapolation of existing ground equipment Tables 7-54 through 7-56 summarize the weight which are logistic options.

7.17 GENERAL PURPOSE LABORATORY (FC 18.00)

The General Purpose Laboratory provides the capability to perform and support experiments, as well as support for operations and maintenance of Space Station subsystems. It contains the equipment and facilities required to support, service, and maintain RAMS. The GPL is physically divided into six laboratories and facilities with representative facilities illustrated in Figure 7-23.

A. Data Evaluation Facility
B. Optical Sciences Laboratory
C. Electronic/Electrical Laboratory
D. Experiment and Test Isolation Laboratory
E. Hard Data Processing Facility
F. Mechanical Sciences Laboratory

The first is the Data Evaluation Facility which contains equipment to analyze, reconstruct, mensurate, store and retrieve experimental and operational data. The Data Evaluation Facility works in conjunction with the Space

Table 7-50

CREW EQUIPMENT AND LIFE SUPPORT SPECIFICATIONS

Provisions:	6 man crew for 90 days	
Food Storage:	Routine—30 days (Crew/Ops Module) Contingency—30 days (ISS Proper) Replenishment—30 days (Logistics Module)	
Food Design:	6-man, 30 days; crewman weight of kg and volume of 0.5 m^3	
Food Water Requirements:	1.33 Kg/man/day (2.94 lbs/man/day)	
Diet:	11.7 MJ (2,800 Kcal)/man/day	
EVA:	Prebreathing of O_2 for 3 hours; maximum EVA—3 hours	
Emergency Oxygen:	15 minutes supply per portable bottle; 96-hr supply by emergency pallet	
Private Quarters:	Minimum volume of 2.1 m x 2.1 m x 1.2 m	
Minimum Free Volume Per Compartment:	2m x 2m x 1m	
Either Male or Female Crew Members		
Hygiene/Waste Management:	2 enclosed facilities	
Hygiene Compartment Volumes:	Shower	1.7 m^3
	Waste Management	1.8 m^3
	Urinal/Handwash	0.85 m^3
	Laundry	0.56 m^3
	Free Space	1.80 m^3
		6.7 m^3
Command Center Volumes:	Equipment	3.1 m^3
	Operating Space	3.0 m^3
		6.1 m^3
Wardroom, Galley and Gym:	Minimum volume of 40 m^3	
Medical Support:	An assembly shall be provided for first aid, resuscitation and support type measures • Alternate escape routes • Fire prevention and suppressant equipment • Strategically located IVA and EVA suits • Meteoroid and radiation protection and detection.	

Table 7-51

CREW LIFE SUPPORT AND FURNISHINGS DETAIL WEIGHT SUMMARY FOR POWER MODULE

		Unit Weight	Total ISS Req	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight		
14.01	Restraints and Handrails						79		
	Restraints							10	
	Foot	1	16			3			3
	Tethers	0.1	40			5			1
	Pelvis	3	12			2			6
	Handrails	--	--	--	--	--		69	
14.02	Crew Life Support								
	Hygiene Facilities						--	--	
	Urinals	8	4						
	Fecal Collectors/Stow	58	2			--			--
	Fecal H_2O Collector	16	1			--			--
	Chamber Sink and Dryer	12	2			--			--
	Shower	30	2			--			--
	Clothing Washer/Dryer	75	1			--			--
	Miscellaneous	--	--			--			--
	Water Management							--	
	Urine Water Recovery	295	1			--			--
	Wash Water and Condition Recovery	85	1			--			--
	Recovered H_2O Storage	150	1			--			--
	Contingency H_2O	340	3			--			--
	Food Management						--		
	Oven	62	1			--			--
	Dishwasher/Dryer	63	1			--			--
	Utensils	--	--			--			--
	Food	--	--			--			--
	Freezer	40	1			--			--
	Refrigerator	38	1			--			--
	Dry Food Stowage	35	2			--			--
	Housekeeping							--	
	Vacuum Cleaner	20	2			--			--
	Wipes	--	220			--			--
	Towels	--	18			--			--
	Trash Mangement							--	
	Dryer	60	1			--			--
	Trash Compactor	160	1			--			--
	Cannister	14.8	12			--			--
	Bags and Liners	--	180			--			--
	Spares	--	--	--	TBD	--		--	
14.03	Cargo Handling	--	--	--	--	--	51		
14.04	Furnishings						195		
	Partitions	--	--			--		--	
	Doors	6	12			--		--	
	Consoles	--	--			--		93	
	Floor	--	--			--		--	
	Equipment							--	
	Wardroom Table	17	1			--	--		--
	Desks	16	6			--	--		--
	Bunks	16	6			--	--		--
	Paint	--	--					15	
	Lighting (Interior)							87	
	Area	2	123			30			60
	Handrail	1	70			20			20
	Supplementary	1	55			5			5
	Portable	2	5			1			2
	High Intensity	3	2			--			
	Lighting (Exterior)							100	
	Docking	2	40			20			40
	Orientation	5	12			4			20
	Acquisition	10	12			4			40
14.00	Crew Life Support and Furnishings						425 (193 kg)		

Table 7-52

CREW LIFE SUPPORT AND INTERIORS DETAIL WEIGHT SUMMARY FOR CREW MODULE

			Total	Logistic Options		Initial Launch			
		Unit Weight	ISS Req	Quantity	Total Weight	Quantity	Total Weight		
14.01	Restraints and Handrails						71		
	Restraints							10	
	Foot	1	16			3			3
	Tethers	0.1	40			5			
	Pelvis	3	12			2			6
	Handrails	--	--	--	--	--		61	
14.02	Crew Life Support						978		
	Hygiene Facilities							323	
	Urinals	8	4			4			32
	Fecal Collectors/Stow	58	2			2			116
	Fecal H_2O Collector	16	1			1			16
	Chamber Sink and Dryer	12	2			2			24
	Shower	30	2			2			60
	Clothing Washer/Dryer	75	1			1			75
	Miscellaneous	--	--						
	Water Management							530	
	Urine Water Recovery	295	1			1			295
	Wash Water and Condition Recovery	85	1			1			85
	Rcovered H_2O Storage	150	1			1			150
	Contingency H_2O	340	3	--	--	--			--
	Food Management (Nom)							125	
	Oven	62	1	--	--	1			62
	Diswasher/Dryer	63	1	--	--	1			63
	Utensils	--	--	--	38	--			--
	Food	--	--	180 Mid	529	--			--
	Freezer	40	1	1	40	--			--
	Refrigerator	38	1	1	38	--			--
	Dry Food Stowage	35	6	2	70	--			--
	Housekeeping							--	
	Vacuum Cleaner	20	2	2	40	--			--
	Wipes	--	220	--	64	--			--
	Towels	--	18	18	9	--			--
	Trash Management							--	
	Dryer	60	1	1	60	--			--
	Trash Compactor	160	1	1	160	--			--
	Cannister	14.8	12	12	178	--			--
	Bags and Liners	--	180	180	18	--			--
	Spares	--	--		TBD	--		--	
14.03	Cargo Handling	--	--	--	--	--	51		
14.04	Furnishings						1,468		
	Partitions	--	--			--		573	
	Doors	6	12			12		72	
	Consoles (25% Cont)	--	--					215	
	Floor	--	--					233	
	Equipment							113	
	Wardroom Table	17	1	--	--	1			17
	Desks	16	6	--	--	6			96
	Bunks	5	6	6	30	--			--
	Paint	--	--					17	
	Lighting (Interior)							153	
	Area	2	123			48			96
	Handrail	1	70			25			25
	Supplementary	1	55			25			25
	Portable	2	5			2			4
	High Intensity	3	2			1			3
	Lighting (Exterior)							92	
	Docking	2	40			16			32
	Orientation	5	12			4			20
	Acquisition	10	12			4			40
14.00	Crew Life Support and Furnishings				1,274		2,568 (1,164 kg)		

Table 7-53

CREW LIFE SUPPORT AND FURNISHINGS DETAIL WEIGHT SUMMARY FOR GPL MODULE

		Unit Weight	Total ISS Req	Logistic Options: Quantity	Logistic Options: Total Weight	Initial Launch: Quantity	Initial Launch: Total Weight		
14.01	Restraints and Handrails						71		
	Restraints							10	
	Foot	1	16			3			3
	Tethers	0.1	40			5			1
	Pelvis	3	12			2			6
	Handrails	--	--	--	--	--		61	
14.02	Crew Life Support						--		
	Hygience Facilities							--	
	Urinals	8	4			--			--
	Fecal Collectors/Stow	58	2			--			--
	Fecal H_2O Collector	16	1			--			--
	Chamber Sink and Dryer	12	2			--			--
	Shower	30	2			--			--
	Clothing Washer/Dryer	75	1			--			--
	Miscellaneous	--	--			--			--
	Water Management							--	
	Urine Water Recovery	295	1			--			--
	Wash Water and Condition Recovery	85	1			--			--
	Recovered H_2O Storage	150	1			--			--
	Contingency H_2O	340	3	3	1,020				--
	Food Management (Cont)								
	Oven	62	1			--			--
	Dishwasher/Dryer	63	1			--			--
	Utensils	--	--	--	-	--			--
	Food	--	--	180 MD	529	--			--
	Freezer	40	1	--	--	--			--
	Refrigerator	38	1	--	--	--			--
	Dry Food Stowage	35	6	4	140	--			--
	Housekeeping							--	
	Vacuum Cleaner	20	2			--			--
	Wipes	--	220			--			--
	Towels	--	18			--			--
	Trash Management							--	
	Dryer	60	1			--			--
	Trash Compactor	160	1			--			--
	Cannister	14.8	12			--			--
	Bags and Liners	--	180			--			--
	Spares	--	--	--	TBD	--		--	
14.03	Cargo Handling	--	--	--	--		20		
14.04	Furnishings						574		
	Partitions	--	--			--		--	
	Doors	5	12			--		--	
	Consoles	--	--			--		118	
	Floor	--	--			--		224	
	Equipment							--	
	Wardroom Table	17	1			--			--
	Desks	16	6			--			--
	Bunks	5	6			--			--
	Paint	--	--	--	--	--		17	
	Lighting (Interior)							147	
	Air	2	123			45			90
	Handrail	1	70			25			25
	Supplementary	1	55			25			25
	Portable	2	5			2			4
	High Intensity	3	2			1			3
	Lighting (Exterior)							68	
	Docking	2	40			4			8
	Orientation	5	12			4			20
	Acquisition	10	12			4			40
14.00	Crew Life Support and Furnishings				1,689		665 (302 kg)		

Table 7-54

CREW EQUIPMENT DETAIL WEIGHT SUMMARY FOR POWER MODULE

		Total Weight	Total ISS REQ	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity		Initial Launch Total Weight
17.02	Personal Gear					--	--	--
	Personal Hygiene							
	Shaver	0.6	6	--	--			
	Grooming Kit	2.5	6	--	--			
	Garments, Etc.							--
	Garments (180 MD)			--	--			
	Bed Rolls	3.5	6	--	--			
	Towels, Wipes, Etc.	--	--	--	--			
	Miscellaneous					--		--
	Portable Life Supt Units	103	4	2	206			
	O_2 Mask	7	6	--	--			
	IVA/EVA Life Supt	46	4	2	92			
	IVA Support	10	3	1	10			
	Pressure Suits (Spares)	20	6	2	40			
17.03	Crew Support					--	--	
	Medical Provisions	200	2	--	--			--
	Off Duty Provisions	375	1	--	--			--
17.04	Crew Accessories					--	--	
	Fire Extinguishers	25	3	1	25			--
	Tools	25	1	--	--			--

Table 7-55

CREW EQUIPMENT DETAIL WEIGHT SUMMARY FOR CREW MODULE

	Total Weight	Total ISS REQ	Logistic Options		Initial Launch		
			Quantity	Total Weight	Quantity		Total Weight
17.02 Personal Gear					--	--	
Personal Hygiene							--
Shaver	0.6	6	6	4			
Grooming Kit	2.5	6	6	15			
Garments, Etc.							--
Garments (180 MD)			--	42			
Bed Rools	3.5	6	6	21			
Towels, Wipes, Etc.	--	--	--	5			
Miscellaneous							--
Portable Life Supt Units	103	4	2	206			
O_2 Mask	7	6	6	42			
IVA/EVA Life Supt	46	4	2	92			
IVA Support	10	3	1	10			
Pressure Suits (Spares)	20	6	2	40			
17.03 Crew Support					--	--	
Medical Provisions	200	2	1	100			--
Off Duty Provisions	375	1	1	375			--
17.04 Crew Accessories					--	--	
Fire Extinguishers	25	3	1	25			--
Tools	25	1	--	--			--

Table 7-56

CREW EQUIPMENT DETAIL WEIGHT SUMMARY FOR GPL MODULE

		Total Weight	Total ISS REQ	Logistic Options Quantity	Logistic Options Total Weight	Initial Launch Quantity	Initial Launch Total Weight
17.02	Personnal Gear					--	--
	Personal Hygiene						--
	Shaver	0.6	6	--	--		
	Grooming Kit	2.5	6	--	--		
	Garments, Etc.						--
	Garments (180 MD)			--	--		
	Bed Rolls	3.5	6	--	--		
	Towels, Wipes, Etc.	--	--	--	--		
	Miscellaneous						--
	Portable Life Supt Units	103	4	--	--		
	O_2 Mask	7	6	--	--		
	IVA/EVA Life Supt	46	4	--	--		
	IVA Support	10	3	1	10		
	Pressure Suits (Spares)	20	6	--	--	--	
17.03	Crew Support						--
	Medical Provisions	200	2	1	100		--
	Off Duty Provisions	375	1	--	--		--
17.04	Crew Accessories					--	
	Fire Extinguishers	25	3	1	25		--
	Tools	25	1	1	25		--

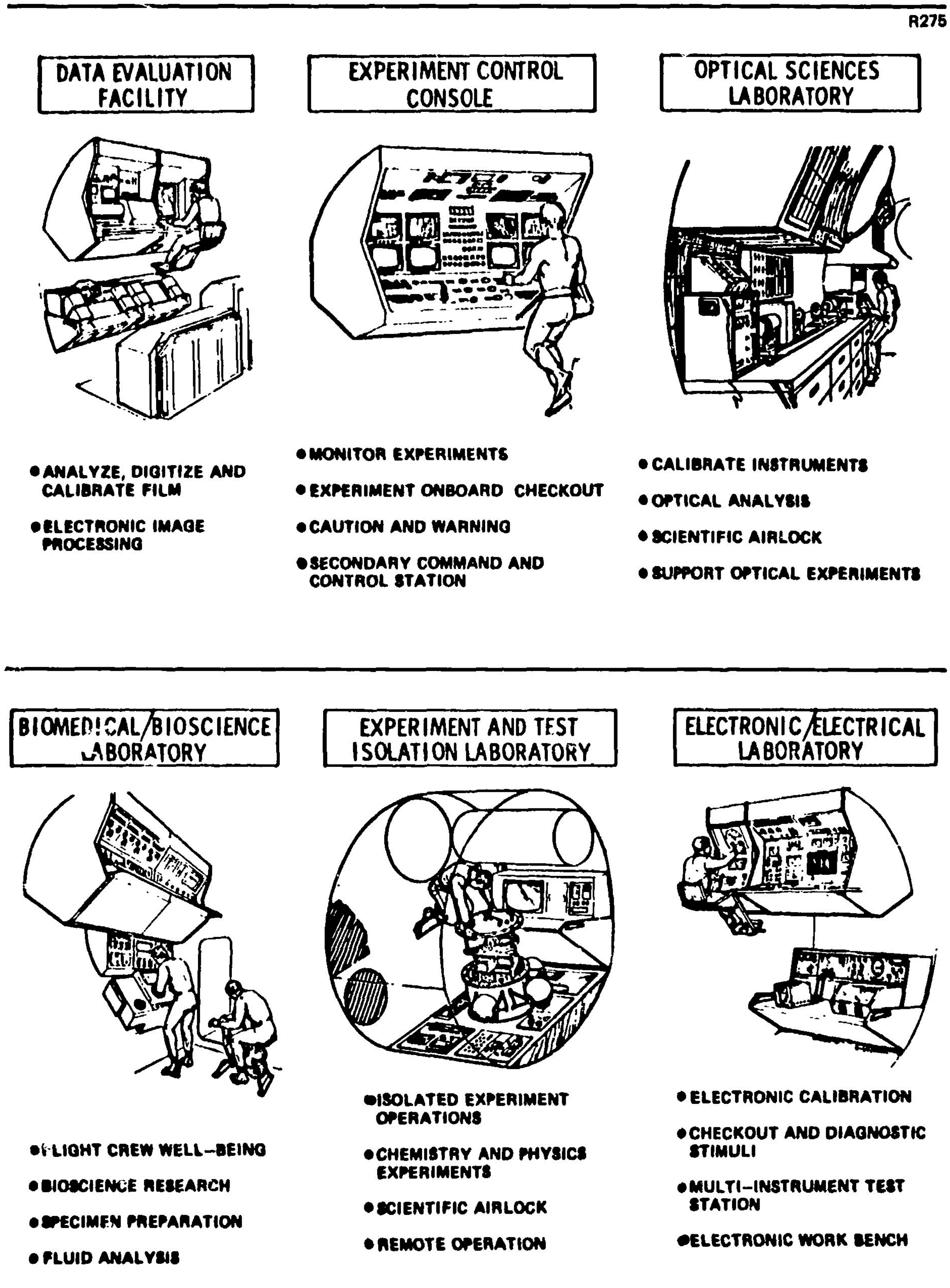


Figure 7-23. GPL Provisions

Station Data Management System to make up a complete complete complement of hardware and software for Space Station data handling capability. Significant portions of the Data Management System are physically located in the Data Evaluation Facility.

The Data Evaluation Facilities include those functions or capabilities that are logically related or associated with the availability of film, video, analog and digital data, the handling and processing and the evaluation of such such data.

The next is the optical Sciences Laboratory which contains optical test, calibration, and alignment equipment. This equipment supports a wide range of experiments, and experiment and operational equipment such as: contamination, telescopes, cameras, scanners, navigation equipment, stabilization equipment, electronic imagers, rendezvous and tracking equipment and any other gear that requires optical or spectral alignment, calibration, troublehsooting or set-up.

The Optical Sciences Laboratory contains a scientific airlock chamber for performance and deployment of experiments. Associated with the airlock chamber is an optically flat broad spectrum transmission window which allows viewing and photography of deployed experiments and external phenomena. The scientific airlock chamber will accept an 18 in. -diameter experiment package. A small experiment and airlock display and control unit is mounted adjacent to the airlock with the appropriate interfaces provided.

The third is the Electronic/Electrical Laboratory which will support both experiments and operational subsystems. The main service facility in the Electronic/Electrical Laboratory is the multi-instrument test bench. This test bench and console will provide the capability for bench checkout, calibration, and contingency repair of electronics and electrical equipment. Built into the bench is a miniature laminar flow glove box for cleaning, assembling, disassembling and soldering. The multi-instrument test bench contains storage for hand tools required for contingency bench level work on electronic equipment. As in all other GPL laboratories and facilities the equipment will be built modular so that carry-on equipment can be utilized an and the laboratory can be reconfigured.

The Experiment and Test Isolation Laboratory includes the facilities to do experiments, maintenance and operations isolated from the Space Station environment. It provides the capability to isolate toxic liquids, gases, molten solid materials and high pressures. An airlock chamber is in the laboratory for experiments involving exposure to environment other than that in the Space Station. A chemistry and physics glove box and a storage and analysis console is located in the laboratory to provide enclosed work stations for experiments and operations involving chemical handling and other similar type functions. A heat exchanger is provided as part of the airlock chamber for heat transfer to the Space Station radiator from high-temperature experiments.

The Hard Data Processing Facility includes the capabilities and all the equipment related to film availability, film handling and processing, preliminary film calibration and "quick look" film data evaluation. The Hard Data Processing Facility provides basic services, and as such supports all experiments and operations utilizing film. Film storage is in the Hard Data Processing Facility. The film storage cabinet will provide radiation protection as well as temperature stabilization. A light table with integral densitometer and a spectral color analyzer will be provided to take film test strip data.

The Mechanical Sciences Laboratory supports a wide range of experimental and operational functions. Many types of mechanical, electro-mechanical and chemical functions must be accommodated by the equipment in this laboratory. The Mechanical Sciences Laboratory features laminar flow glove boxes with chemical and gas capabilities for heavy duty, light duty, and specialized functions. The glove boxes are utilized for assembly, disassembly, repair, replacement, purging, cleaning, lubricating, and calibration of items of subassembly size. These glove boxes provide zero g hold down for items subject to disassembly, as well as the removal of elements and replace replacement spares/consumables involved under the lighting and clean room conditions necessary for the protection of flight crews and reliability of items receiving maintenance attention. Work benches will provide the stowage for hand tools and maintenance consumables used frequently. Stowage is provided in this facility for shop tools and specialized spares.

The Mechanical Laboratory also contains equipment such as the metallograph tester, thermo-structural tester, x-ray diffraction unit, x-ray generator, and specimen structural tester for performance and analysis of materials science experiments. This equipment is the type of general-purpose equipment found in a well-equipped mechanical research lab, and therefore is included as part of the GPL.

The Biomedical/Bioscience Laboratory is a rudimentary facility for monitoring of astronaut well being, microbiological research, plant physiology and invertebrate research. The biomedical equipment will have the capability to measure such things as heart functions with an electrocardiogram and a vectorcardiogram, work performance with a bicycle ergometer, body mass with a body mass measurement device, and effects on the physiology of using a lower body negative pressure device. Equipment is also available in a biochemical and biophysical analysis unit for "zero-g" blood and urine analysis. A biological glove box is provided for biological work requiring isolation or separation from the Space Station environment due either to toxicity or contamination.

Table 7-57 summarizing the weights which were extracted from similar ground units.

Table 7-57

GENERAL PURPOSE LABORATORY DETAIL WEIGHT SUMMARY FOR GPL MODULE

	Unit Weight	Total ISS Req	Logistic Options: Quantity	Logistic Options: Total Weight	Initial Launch: Quantity	Initial Launch: Total Weight
18.01 Hard Data Processing Facility						265
Film Processor (Rapid)	50	1		-	1	50
Film and Plate Processor (Color)	97	1		-	1	97
Film Processor (B&W)	73	1		-	1	73
Film Stowage/Vault	5,000	1	1	5000		-
Micro Filmer	50	1	1	50		-
Light Table	50	1	1	50		-
Spectro Photometer	10	1	1	10		-
Densitometer	20	1	1	20		-
Operation Console	45	1		-		45
18.02 Electronic Laboratory						405
Electronic Work Station	99	1		-		99
Multi-Inst Test Bench	198	1		-		198
Battery Charger	50	1	1	50		-
Hi-Voltage Source	99	1		-		99
Hi-Energy Counter Cal Equipment	50	1	1	50		-
Miniature Glove Box	20	1		-		9
18.03 Experiment and Test Isolation Lab						842
Hazard Detection System	30			-		30
Electrical and Vac Pwr Center	60			-		60
Hydraulic/Pneumatic Work Station	174			-		174
Cryogenic and Flugid Stow	50			50		-
High Pressure Gas Stow	50			50		-
Airlock/Environmental Chamber	503			-		503
Chemistry and Physic Glove Box	75			-		75
18.04 Optical Sciences Laboratory						544
Optical Work Station	99			-		99
Optical Bench	198			-		198
Precision Work Fixtures	50			50		-
Microdensitometer	20			20		-
Monochromator Spectrometer	20			20		-
Mod Xsfr Meas System	20			20		-
Optical Spectrum Analyzer	20			20		-
Scientific Airlock	247			-		247
18.05 Mechanical Laboratory						431
Mechanical Workbench	174	1		-	1	174
Exp and Isol Test Lab Mont Panel	60	1		-	1	60
Laminar Flow Fac Glove Box	99	1		-	1	99
Specimen Structure Tester	98	1		-	1	98
X-Ray Generator	147	1	1	147		-
Precision Work Fixture	20	1	1	20		-
18.06 Biomedical/Bioscience Laboratory						237
Biochem/Physic Anal Unit	98	1		-	1	98
Bioscience Glove Box	99	1		-	1	99
Bicycle Ergometer	40	1		-	1	40
Lower Body Neg Press Device	39	1	1	39		-
Body Mass Meas Device	40	1	1	40		-
Biomedical D&C Unit	99	1	1	99		-
18.07 Data Evaluation Facility						50
Multi-Format Viewer Editor	147	1	1	147		-
Microfilm Retrieval System	396	1	1	396		-
Copy Machine	99	1		99		-
Stereo Viewer	99	1	1	99		-
Printer	50	1		-	1	50
18.08 Contamination Measurement						101
WB Mass Spectrometer	85	1		-	1	85
Operating Panel	15	1		-	1	15
Miscellaneous	1	1		-	1	1
18.20 Miscellenaous						288
Attaching Hardware				-		
Miscellaneous 10%				-		288
Spares	-	-	-	201		-
General Purpose Laboratory				6,747		3,163 (1,435 kg)

7.18 RESIDUALS (FC 21.00)

Residuals include propellant fuel and pressurization gases as well as radiator fluids trapped in lines, components, and tanks. The initial atmosphere is also included in the functional code since any gas leakage is made up from onboard stores.

Weights were estimated using line lengths and tank-trapped fluids and gases. The atmosphere was defined as the total nomical pressurized volume at 14.7 psi, less 2 percent for volume displaced by internal stores and structures. Table 7-58 summarizes these weights.

Table 7-58

RESIDUAL WEIGHT SUMMARY FOR SPACE STATION MODULES

		Modules					
		Power		Crew		GPL	
21.01	Pressurization Gases	31		--		--	
	Pressurization		20		--		--
	Purge		10		--	--	--
	Lines		1		--	--	--
21.03	Fuel Tapped	41		--		--	
	Tanks		37		--		--
	Lines		4		--		--
21.13	Residuals	417		624		624	
	HYD (Docking)		60		60		24
	Cold Plates and Lines		13		13		13
	Radiator Manifold and Lines		77		120		120
	Atmosphere		319		483		
	Radiator Components		8		8		483
21.00	Residuals	549 (249 kg)		684 (310 kg)		648 (294 kg)	

7.19 IN-FLIGHT LOSSES AND RESERVES (FC 22.00 AND FC 23.00)

The only item in functional code 22.00 is the 30 day reserve propellant. All other reserves are logistic options. In-flight losses are the first 90 days of propellant consumed during the buildup. Table 7-59 summarizes these values.

Table 7-59

RESERVES AND IN-FLIGHT LOSSES WEIGHT SUMMARY

	Modules					
	Power		Crew		GPL	
*22.00 Reserves	223		---		---	
Propellant		223		---		---
**23.00 In-Flight Losses	530		---		---	
Propellant		530		---		---

*(101 kg)
**(240 kg)