JUNE 1971

MDC G2313

SPACE STATION

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

PHASE B

MASS PROPERTY STATUS REPORT

CONTRACT NAS8-25140

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY

MARTIN MARIETTA CORPORATION IBM International Business Machines Corporation MCDONNELL DOUGLAS CORPORATION

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FOREWORD

This is the second Mass Properties Report of the Modular Space Station Phase B Definition. The current report is the first formal reporting on the Baseline Design Configuration that was selected after the initial report was submitted on 27 March 1971.

The Space Station and Logistic Module configuration used for determining the mass properties is defined in the Space Station Baseline Program and System Definition Document, A3-830-BVAO-690, dated 4 May 1971. Basically, the buildup consists of three modules (Power, Crew, and GPL) providing a six-man station (ISS). Normal crew size is five men with the sixth either a principal investigator or maintenance specialist. The nominal resupply cycle is 30 days with the Logistic Module serving as a pantry while on station. Only emergency supplies and a 30-day backup supply will be loaded aboard the Space Station. The 12-man Growth Space Station (GSS) will be reported on when the material becomes available.

Section 1 summarizes the mass of the launched modules' discretionary payload margins and subsystem comparisons.

Section 2 contains the Modular Space Station sequence mass properties to the ISS level.

Section 3 reports the detailed status of the ISS modules.

Section 4 reports the detailed status of the initial Logistics Module and cargo requirements.

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TABLES

Section 1
INTRODUCTION

The format of this report facilitates the review of the Mass Properties Control and Integration Program in accordance with MIL-M-38310A (USAF).

1.1 ISS MODULAR SPACE STATION AND LOGISTIC MODULE MASS SUMMARY

The modular weights are summarized in pounds (mass) and kilograms in Table 1-1 to permit definition of the discretionary payload margins. The Modular Space Station in this report is defined as the Baseline Design Configuration with the detailed mass properties summarized in Section 3. The Logistic Module detailed mass properties are contained in Section 4. The summary of all launched mass necessary for initial manning plus a 3-man crew is 31, 569 kg (70, 095 lbm) or 4, 719 kg (9, 905 lbm) less than the available mass.

Table 1-2 summarizes the subsystem mass for the ISS Power, Crew, GPL, and Logistic Modules

1.2 MODULAR SPACE STATION AND LOGISTIC MODULE MASS CHANGE SUMMARY

In the next report, this section will contain a change analysis summary. The current configuration will serve as the baseline to report all future mass-properties changes.

Table 1-1

GROSS DISCRETIONARY PAYLOAD

Description	Mass (kg)		Mass (lbm)	
① Module, Minimum Launch	23, 546		51, 908	
Power Module		8, 230		18, 143
Crew Module		7, 407		16, 331
GPL Module		7, 909		17, 434
② Logistic supplement	4, 100		9, 039	
Power Module		1, 659		3, 657
Crew Module		1, 627		3, 587
GPL Module		814		1, 795
② Logistic support	3, 923		9, 148	
Logistic Module		2, 947		6, 497
Cargo requirement		637		1, 904
Crew (3)		339		747
Total manning mass	31, 569		70, 095	
Discretionary margin	4, 719		9, 905	
Total target capability	36, 288		80, 000	

① See Section 3 for additional details
② See Section 4 for additional details.

Table 1-2

SPACE STATION AND LOGISTIC MODULAR SUBSYSTEM MASS SUMMARY

Code	Description	Power Module No. 1		Crew Module No. 1		GPL Module		Logistic Module and Cargo	
		Mass (lbm)	(kg)	Mass (lbm)	(kg)	Mass (lbm)	(kg)	Mass (lbm)	(kg)
02.00	Structure	3,042	1,380	3,909	1,773	4,246	1,926	2,725	1,236
03.00	Meteoroid/thermal protection	1,080	490	1,989	902	1,781	808	961	436
04.00	Docking provisions	1,265	574	1,279	580	322	146	511	232
06.00	Propulsion	1,003	455	448	203	176	80	174	79
07.00	Prime power	5,902	2,677	15	7	15	7	--	--
08.00	Power conditioning and distribution	631	286	309	140	286	130	280	127
10.00	Electronics	1,285	583	2,185	991	2,436	1,105	657	298
11.00	Wiring	864	392	1,292	586	1,413	641	439	199
12.00	Atmosphere and thermal control	1,272	577	1,268	575	1,563	709	159	72
14.00	Crew life support and interiors	392	178	2,733	1,240	842	382	326	148
17.00	Crew equipment and crew	24	11	176	80	24	11	24	11
18.00	GPL and experiment provisions or cargo	--	--	--	--	3,602	1,634	11,190	5,076
21.00	Residuals	437	198	728	330	728	330	240	109
22.00	Reserves	320	145	--	--	--	--	--	--
23.00	Inflight losses	626	284	--	--	--	--	--	--
	Minimum-Launch Total	18,143	8,230	16,331	7,407	17,434	7,909	17,686	8,023
	Discretionary Margin	1,857	842	3,669	1,665	2,566	1,163	2,314	1,049
	Target	20,000	9,072	20,000	9,072	20,000	9,072	20,000	9,072

Section 2
ORBITING AND LAUNCH VEHICLE

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

Table 2-1 is a sequence mass properties summary starting with the Power Module, then the Crew Module, the GPL Module, and the Logistic Modules. The first Logistic Module supplies expendables for a three-man crew and associated crew manning provisions. This is followed 30 days later with a second Logistic Module and two additional crewmen (Figure 2-1).

The longitudinal cg excursion limits as defined by the Orbiter are noted on Figure 2-2. The lateral (Y) and vertical (Z) axis limits are ±0.15 meter (6 inches) about the Orbiter cargo bay centerline. Currently, the Crew and GPL Modules exceed the lateral and vertical limits. This is considered a minor problem and during the next reporting period the internal provisions will be relocated to conform to the limits.

Table 2-1

ORBITING SPACE STATION VEHICLE SEQUENCE MASS PROPERTIES

Description	Current Mass (kg)	Center of Gravity (Ref OV STA 100.0)			Moment of Inertia (kg M^2 x 10^{-3})			Products of Inertia (kg M^2 x 10^{-3})		
		X	Y	Z	Roll	Pitch	Yaw	Roll	Pitch	Yaw
Power Module No. 1	9,072	108.27	0.051	0.068	30.3	318.5	383.4			
Propellant	-78	107.20	0	0	--	--	--			
Crew Module No. 1	+9,072	93.43	0.21	-0.18	31.2	162.7	162.7			
Space Station After Crew Module Docked	18,066	100.82	0.13	-0.56	61.9	1,476.7	1,541.4	-178.3	16.7	-10.6
Propellant	-94	107.20	0	0	--	--	--			
GPL	+9,072	92.92	0.05	-9.80	162.8	162.8	31.2			
Space Station After GPL Module Docked	27,044	98.15	0.10	-3.33	796.7	2,582.8	1,945.2	4.7	479.9	-6.7
Propellant	-142	107.20	0	0						
Logistic Module No. 1	+9,072	93.14	-5.45	3.15	42.8	49.3	28.5			
Space Station After Logistic Module Docked	35,974	96.85	-1.30	-1.71	1,332.8	3,071.0	2,337.0	-239.8	257.6	179.9
Crew (3)	+339	93.14	0	0						
D&C Checkout Units	+45	106.10	-1.40	-0.50						
D&C Checkout Units (2)	+90	92.44	0	-10.34						
Batteries (4)	+724	95.99	1.60	0.20						
Batteries (4)	+724	94.95	0	-11.84						
EVA Gear (3)	+111	106.80	-1.10	-1.5						
CMG's (4)	+728	101.94	0	0						
Repress Gas	+614	100.95	0	0						
Metabolic Gas	+163	100.95	0	0						
Water and Water Management	+211	94.40	-1.2	1.2						
Food and Storage	+158	95.90	-1.7	-0.2						
Trash Management	+101	99.40	-1.2	-1.2						
Housekeeping	+33	98.40	-1.2	-1.2						
Hygiene	+51	97.70	-1.0	-1.0						
Furnishings	+190	93.20	0	0						
Crew Equipment	+48	107.30	0	0						
Off Loaded Logistic	-3,991	93.14	-5.45	3.15						
Space Station After Logistic Module is Unloaded	36,313	97.37	-0.68	-2.30	1,246.3	3,057.3	2,266.5	-148.0	365.1	110.1
Propellant	-109	93.14	-5.45	3.15						
Logistic Module No. 2	+9,072	81.82	0	0	14.1	42.8	42.8			
Space Station After Second Logistic is Docked	45,276	94.488	-0.53	-1.85	1,295.9	4,888.6	4,062.9	-134.0	106.6	33.1

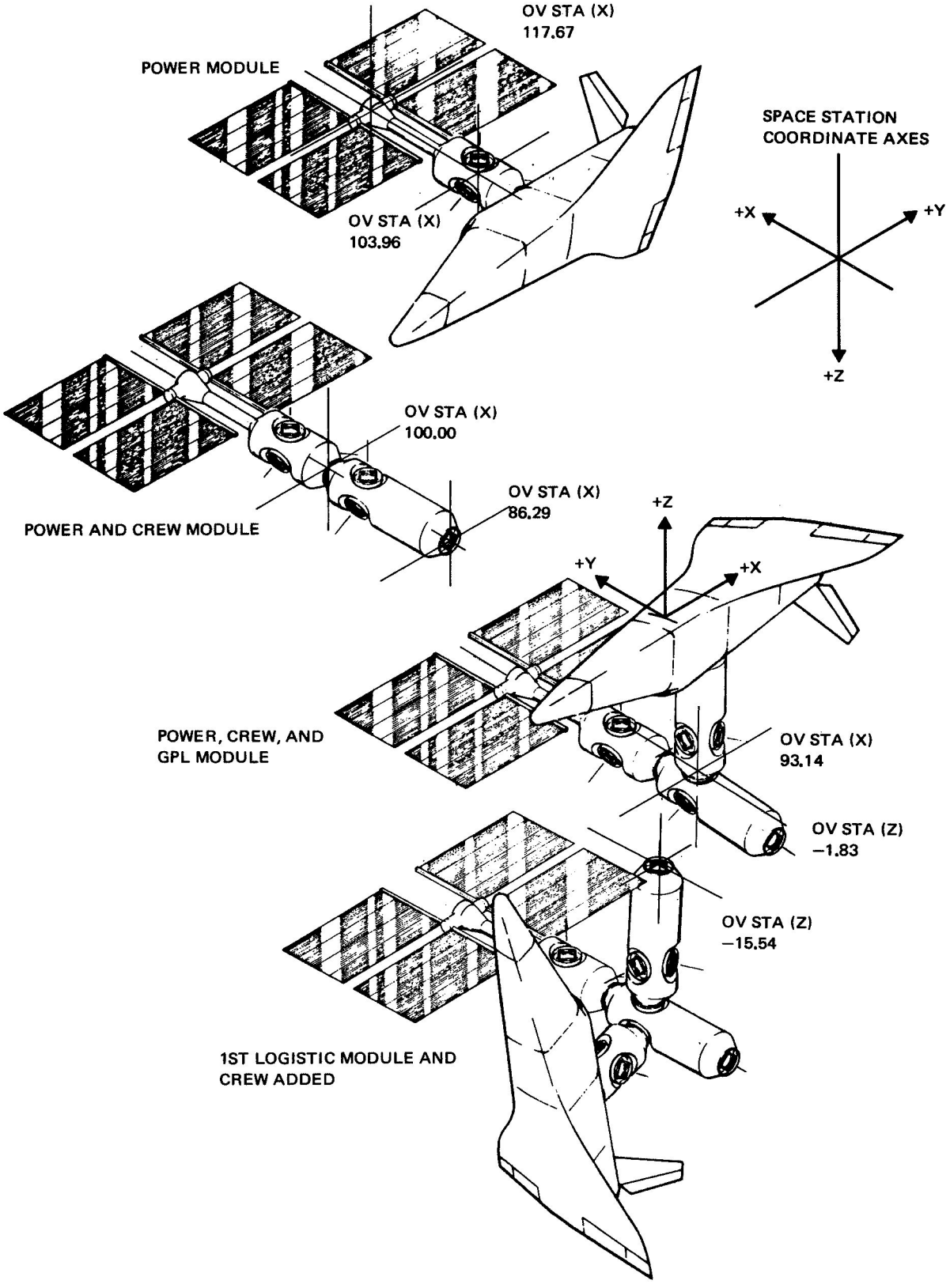


Figure 2-1. Orbiting Vehicle Assembly and CG Station

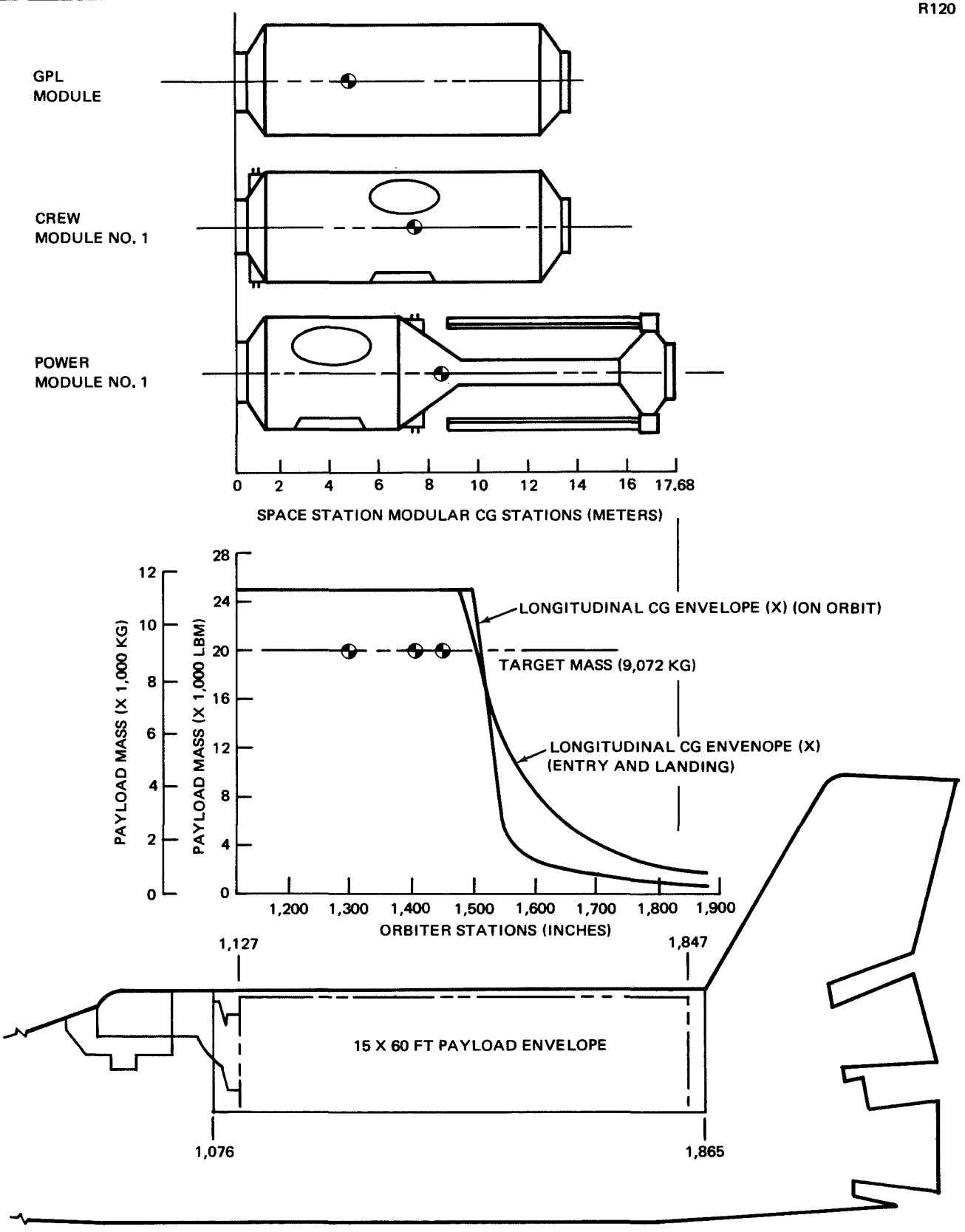


Figure 2-2. Launched Space Station Module CG's and Orbiter-Imposed Limits

Section 3

BASELINE SPACE STATION MODULE CONFIGURATION

The mass properties presented in this section are more detailed than those of the previous sections. They include only the ISS modules; Power, Crew, and GPL. The Logistic Module is summarized in Section 4. This section represents the formal documentation in accordance with MIL-M-38310A.

3.1 ISS INBOARD PROFILE

Figure 3-1 is an inboard profile of the Baseline ISS Configuration. The first unit, the Power Module, provides 22 kw initially; both high and low thrustors, 5 docking ports, storage provisions for onboard CMG's (4), repressurization gases, and metabolic gases. The second unit is the Crew Module which includes both high and low thrustors, 5 docking ports, 6-man crew quarters, galley and wardroom, primary D and C, 6-man EC/LS, and hygiene facility. The GPL Module contains the redundant Station 6-man EC/LS provisions, and also serves as the second pressurizable volume with a secondary D and C center. In addition, a pressure-reversible floor is contained at one end to provide for the isolation and test facility.

3.2 SUMMARY OF REASONS FOR MASS CHANGE

This item will be incorporated in next status report.

3.3 ISS MODULES MASS PROPERTIES SUMMARY

The Space Station modules detailed mass and cg values are summarized in Table 3-1 to the second-generation functional code level. Module moments of inertia are noted in Table 2-1.

3.4 UNRESOLVED PROBLEMS AND IMPROVEMENTS

There are no unresolved problems. A summary of improvement potentials will be incorporated in the next report.

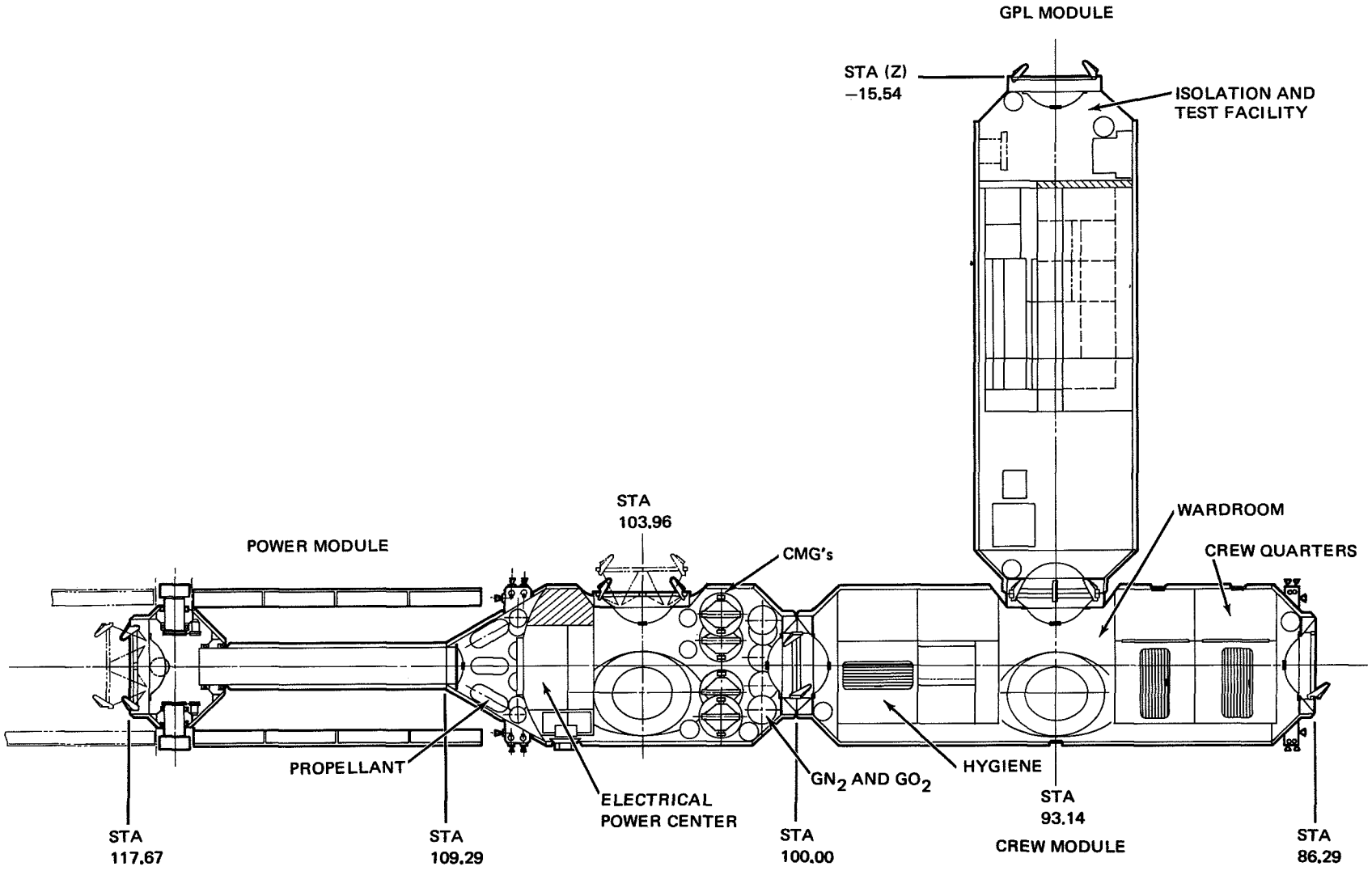


Figure 3-1. ISS Inboard Profile

Table 3-1

ISS MODULE MASS PROPERTY SUMMARY

Code	Description	POWER MODULE NO. 1				CREW 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	1,380	5.07	0.00	0.00	1,773	6.70	0.00	0.00	1,926	5.40	0.00	0.00
02.10	Forward Skirt	126				208				208			
02.11	Pressurized Compartment	1,025				1,324				1,483			
02.12	Aft Skirt	208				208				208			
02.15	Finish, Seals, and Spares	10				20				10			
02.19	Manufacturing Tolerance	11				13				17			
03.00	Meteoroid and Thermal Protection	490	4.00	0.00	0.00	902	6.85	0.00	0.00	808	6.85	0.00	0.00
03.01	Active Thermal Protection	303				552				520			
03.02	Passive Thermal Protection	93				162				162			
03.04	Metheoroid Protection	94				188				94			
04.00	Docking Provisions	574	5.88	0.00	0.00	580	6.85	0.00	0.00	146	6.85	0.00	0.00
06.00	Propulsion	455	7.33	0.00	0.00	203	3.38	0.00	0.00	80	6.80	0.00	0.00
06.01	Thrust System	96				96							
06.07	Fuel Container	158				-				29			
06.09	Pressurization and Control	85				7				7			
06.10	Fuel Distribution and Control	79				79				30			
06.14	Umbilical	5				5				5			
06.15	Support Structure	32				16				9			
07.00	Prime Power	2,677	13.60	0.33	0.20	7	6.80	0.33	0.20	7	3.80	1.10	0.00
07.03	Batteries	731				7				7			
07.04	Solar Array	1,946				-				-			
08.00	Power Conditioning and Distribution	286	6.00	1.30	0.80	140	9.70	1.60	0.20	130	5.00	1.10	0.00
10.00	Electronics	583	6.10	-1.03	-0.07	991	11.50	1.44	-0.09	1,105	5.28	0.98	-0.04
10.01	Guidance and Control	207				48				13			
10.02	Onboard Checkout	139				158				181			
10.03	Data Management	73				329				472			
10.06	Communication	120				30				13			
10.15	Displays and Controls	44				426				426			
11.00	Wiring	392	6.94	-0.59	-0.34	586	9.80	1.10	-1.10	641	5.70	0.00	0.00
12.00	Atmosphere and Thermal Control	577	5.31	0.00	-0.05	575	8.76	-0.90	-1.05	709	6.99	0.55	0.72
12.01	Equipment Thermal Control	148				113				173			
12.02	Atmosphere Control and Supply	228				318				392			
12.03	Radiator Thermal Control	201				144				144			
14.00	Crew Life Support and Interiors	178	3.90	0.00	0.00	1,240	3.32	-0.29	-0.09	382	5.42	0.00	0.00
14.01	Hand Rails and Restraints	18				39				39			
14.02	Crew Life Support Provisions	-				232				-			
14.03	Cargo Handling	23				23				11			
14.04	Interior Furnishings	137				946				332			
17.00	Crew and Crew Equipment	11	1.90	0.00	0.00	80	6.8	1.60	1.00	11	4.50	0.00	0.00
17.01	Crew	-				-				-			
17.02	Personal Gear	-				-				-			
17.03	Crew Gear	-				69				-			
17.04	Crew Accessories	11				11				11			
18.00	GPL and Experiment Provisions (Cargo)	-	-	-	-	-	-	-	-	1,634	5.18	0.07	-0.02
21.00	Residuals	198	4.00	0.00	0.00	330	6.80	0.00	0.00	330	6.80	0.00	0.00
21.01	Fuel Pressurization Gases	36				-							
21.03	Fuel Trapped	10								-			
21.13	Other Residuals	152				330				330			
22.00	Reserve	145	8.00	0.00	0.00	-	-	-	-	-	-	-	-
23.00	In-Flight Losses	284	8.00	0.00	0.00	-	-	-	-	-	-	-	-
23.03	Fuel												
23.07	Service Items												
	Total	8,230	8.270	0.051	0.068	7,407	7.182	0.209	-0.180	7,909	5.743	0.219	+0.054

3.5 INVENTORY OF FLUIDS AND PROPELLANTS LOADED

This data is noted in the pertinent subsystems and will be assembled into a separate table for the next report.

Section 4
BASELINE LOGISTIC MODULE CONFIGURATION

The Baseline Logistic Module contains no provisions for the crew, which is supplied by the Shuttle Orbiter. 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.

4.1 INBOARD PROFILE

An inboard profile of the Logistic Module will be included in the next report. Basically, it is 8.5 meters (28 feet) in length with neuter docking at each end.

4.2 SUMMARY OF REASONS FOR MASS CHANGE

This is the first reporting and, therefore, not applicable.

4.3 LOGISTIC MODULE MASS PROPERTIES SUMMARY

Table 4-1 is a partial mass properties summary of the Logistic Module and the cargo requirements for the first logistic launch. Those items noted as logistic options are defined as items required aboard the Station for manned operation and contingency backup provisions. Examples of the fixed items are CMG's, furnishings, and a repressurization charge. The 30-day column includes the crew and subsystem expendables such as propellant, food, and metabolic oxygen. It should be noted that if all these items are summed together with the additional expendables of 90 man days (3 men x 30 days) for the logistic cycle, they total 5,076 kg (11,190 lbm). This includes the 339 kg mass of 3 crewmen. The logistic module has a mass of 2,947 kg (6,497 lbm), and the combination of module and cargo is 8,023 kg (17,686 lbm), well below the 9,072 kg (20,000 lbm) target.

Table 4-1

LOGISTIC MODULE AND LOGISTIC REQUIREMENTS MASS SUMMARY

Code	Description	LOGISTIC REQUIREMENTS								TOTAL CARGO	LOGISTIC MODULE & CARGO			
		LOGISTIC OPTIONS						Initial Logistic Support (4)		Maximum Logistic Support No. 1 (Tot. of 1, 2, 3 & 4)	Logistic Module No. 1			
		Power Module (1)		Crew Module (2)		GPL Module (3)					Mass (kg)	Center of Gravity (Meters)		
		Fixed	30 Day	Fixed	30 Day	Fixed	30 Day	Misc	30 Day*			X	Y	Z
02.00	Structure	-	-								1,236			
02.10	Forward Skirt										208			
02.11	Pressurized Compartment										799			
02.12	Aft Skirt										208			
02.15	Finish, Seals, and Spares										10			
02.19	Manufacturing Tolerance										11			
03.00	Meteoroid and Thermal Protection	-	-								436			
03.01	Active Thermal Protection										303			
03.02	Passive Thermal Protection										93			
03.04	Meteoroid Protection										40			
04.00	Docking Provisions										232			
06.00	Propulsion	-	-					3	33	36	75			
06.01	Thrust System										-			
06.07	Fuel Container							3	33		-			
06.09	Pressurization and Control										7			
06.10	Fuel Distribution and Control										65			
06.14	Umbilical										5			
06.15	Support Structure										2			
07.00	Prime Power	-	-	724	-	724	-	14		1,462	-			
07.03	Batteries			724		724		14						
07.04	Solar Array			-		-		-		-				
08.00	Power Conditioning and Distribution		-							888	127			
10.00	Electronics	773	-	-		90		25		888	298			
10.01	Guidance and Control	723				-		22			3			
10.02	Onboard Checkout	45				90		3			158			
10.03	Data Management	-				-		-			64			
10.06	Communication	-				-		-			29			
10.15	Displays and Controls	-				-		-			44			
11.00	Wiring	-	-							-	199			
12.00	Atmosphere and Thermal Control	614	163	111				33	163	1,084	72			
12.01	Equipment Thermal Control	-	-	-				-	-		20			
12.02	Atmosphere Control and Supply	614	163	111				33	163		52			
12.03	Radiator Thermal Control	-	-	-				-	-	1,095	-			
14.00	Crew Life Support and Interiors	-	-	429	315			36	315	1,095	148			
14.01	Hand Rails and Restraints			-	-			-	-		18			
14.02	Crew Life Support Provisions			239	315			30	315		-			
14.03	Cargo Handling			-	-			-	-		23			
14.04	Interior Furnishings			190	-			6	-		107			
17.00	Crew and Crew Equipment	-	-	34	14			340	14	402	11			
17.01	Crew			-	-			339	-		-			
17.02	Personal Gear			-	14			-	14		-			
17.03	Crew Gear			34	-			1	-		-			
17.04	Crew Accessories			-	-			-	-		11			
18.00	GPL and Experiment Provisions or (Cargo)	-	-							-	5,076			
21.00	Residuals	-	-								109			
21.01	Fuel Pressurization Gases										-			
21.03	Fuel Trapped										-			
21.13	Other Residuals										109			
22.00	Reserve	-	-											
23.00	In-Flight Losses	-	109							109				
23.03	Fuel		109											
23.07	Service Items		-											
	Total	1,387	272	1,298	329	814	-	451	525	5,076	8,023	4.47	0	0
	On-Orbit Total	1,659		1,627		814		976		5,076	8,023	4.47	0	0

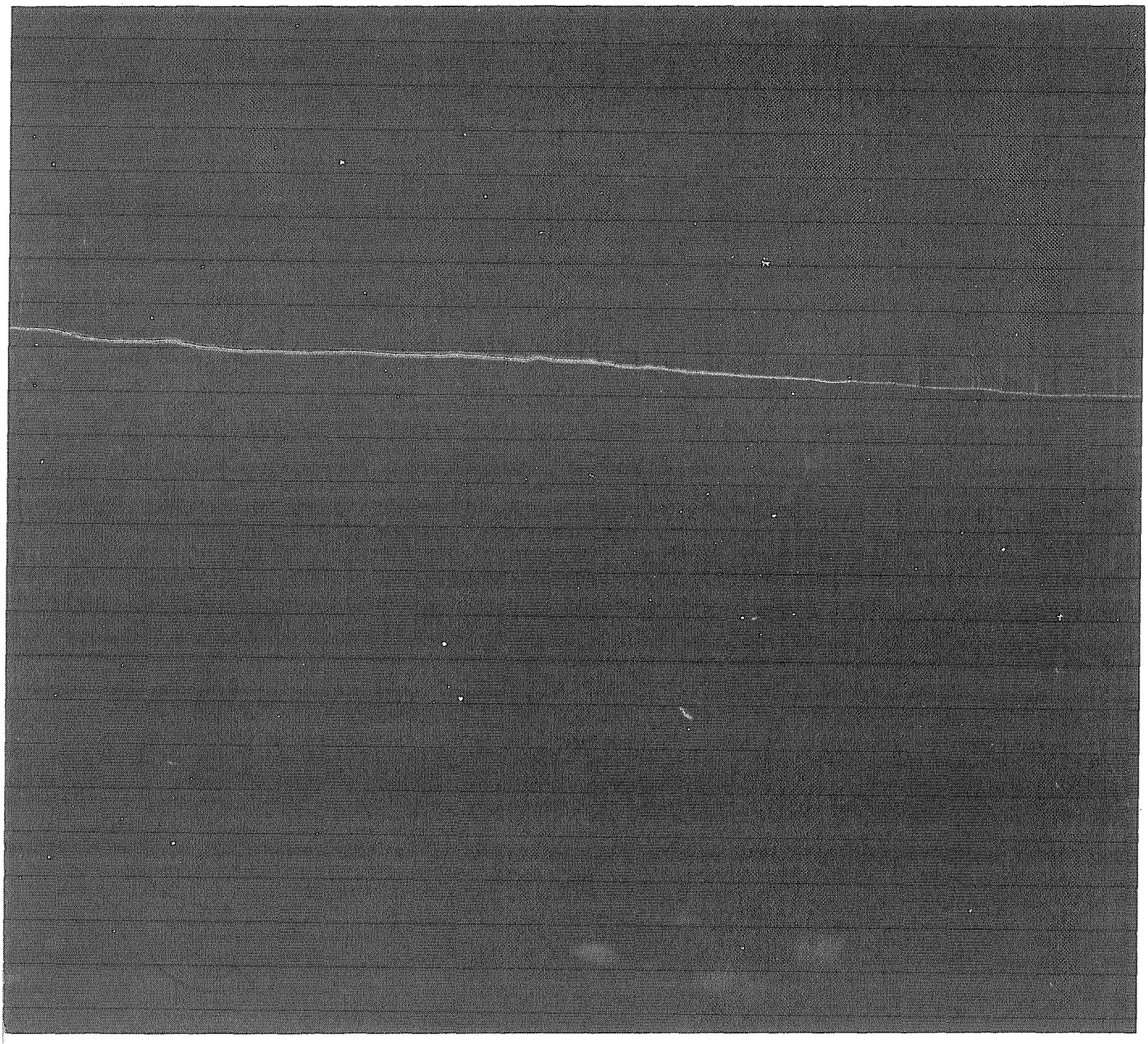
*Three men for 30 days plus contingency for 3 men for 30 days (180 man days).
Second Logistic Module contains expendables for five crew men for 60 days plus contingency for 2 additional men for 30 days (360 man days).

4.4 UNRESOLVED PROBLEMS AND IMPROVEMENTS

There are no unresolved problems. Improvement potentials will be discussed in next report.

4.5 INVENTORY OF FLUIDS AND PROPELLANTS LOADED

This data is included in the pertinent subsystem, but will be presented in greater detail in later reports.



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