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CONTRACT REQUIREMENTS	CONTRACT ITEM	MODEL	CONTRACT NO.	DATE
Exhibit E, Para.5.15.1	Line Item 13.0	LEM	NAS 9-1100	10/4/65

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REPORT

NO. LSR-490-35

DATE: 1 August 1966

LEM MONTHLY MASS PROPERTY STATUS REPORT [redacted]

CODE 26512

PREPARED BY:
R. Aeder

CHECKED BY:
F. Hyatt

APPROVED BY:
T. J. Kelly

REVISIONS

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INTRODUCTION

This report contains the LEM Mass Properties status as of July 19, 1966 for the Lunar Landed Vehicle. The total weight at Separation is 30,824.9 pounds, which is 262.4 pounds lighter than that previously reported in LSR-490-34, dated 1 July 1966.

A summary of changes since the last report is as follows:

A.	Ascent stage inert* weight	-14.6	pounds
B.	Ascent stage propellant	-14.4	pounds
C.	Descent stage inert* weight	-93.5	pounds
D.	Descent stage propellant	-139.9	pounds
Total LEM Weight Change at Separation		-262.4	pounds

A more detailed breakdown of the changes since the last report is included on page 12. Changes in this report are primarily as follows:

A. Additional Super Weight Improvement Program weight savings.

B. General updating of weight based on current data.

The listing of Government Furnished Equipment (GFE) and their weights, shown in Table 6 of the previous weight status report, are still applicable.

The assumed ΔV Budget of 13,918 fps. for the LEM Reference Mission has a distribution of 6586 fps. during the Ascent phase and 7332 fps. during the Descent phase. This budget uses the Concentric Flight Plan and is unchanged since the last report. The reference mission requires more propellant than the critical abort mission, which was defined in LEM Mass Property Report LED-490-23.

* Inert weight includes all non-propulsion expendables.

INTRODUCTION - Cont.

The currently reported ΔV propellant is based on a powered ascent integrated average I_{sp} of 304.3 sec., and a descent phase integrated average I_{sp} of 298.6 sec.. The 304.3 sec. ascent I_{sp} is based on a continuous - burn RCS Thrust Chamber Assemblies I_{sp} of 273 sec., and an ascent engine average I_{sp} of 306.3 sec.. Grumman estimates that the current 3 minimum performance values for the Main engines are as follows:

Ascent Engine I_{sp} = 308.5 sec.

Descent Engine I_{sp} = (Integrated) = 298.6

The manufacturer's current continuous Burn RCS nominal I_{sp} is 273 sec..

Scrape effort on 1032 pounds of ascent structure and 923 pounds of descent structure indicates current potential weight savings of 137.5 pounds and 146.2 pounds, respectively. The 17.0 pound ascent and 4.5 pound descent structure weight savings incorporated in this report brings the total incorporated structure weight savings to 143.5 pounds ascent and 139.5 pounds descent. The 3.5 pound ascent and 1.3 pound descent crew provision weight savings incorporated in this report brings the total incorporated crew provision drawing weight savings to 8.6 pounds ascent and 1.3 pounds descent. The total scrape weight saving incorporated to date is 152.1 pounds from the ascent stage and 140.8 pounds from the descent stage.

The other SWIP item incorporated in this report reduces the descent stage 87.3 pounds. A listing of SWIP items incorporated in weight reports to date is included as Appendix A of this report.

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Figure 1

LEM ALLOWABLE STAGE WEIGHT APPORTIONMENT

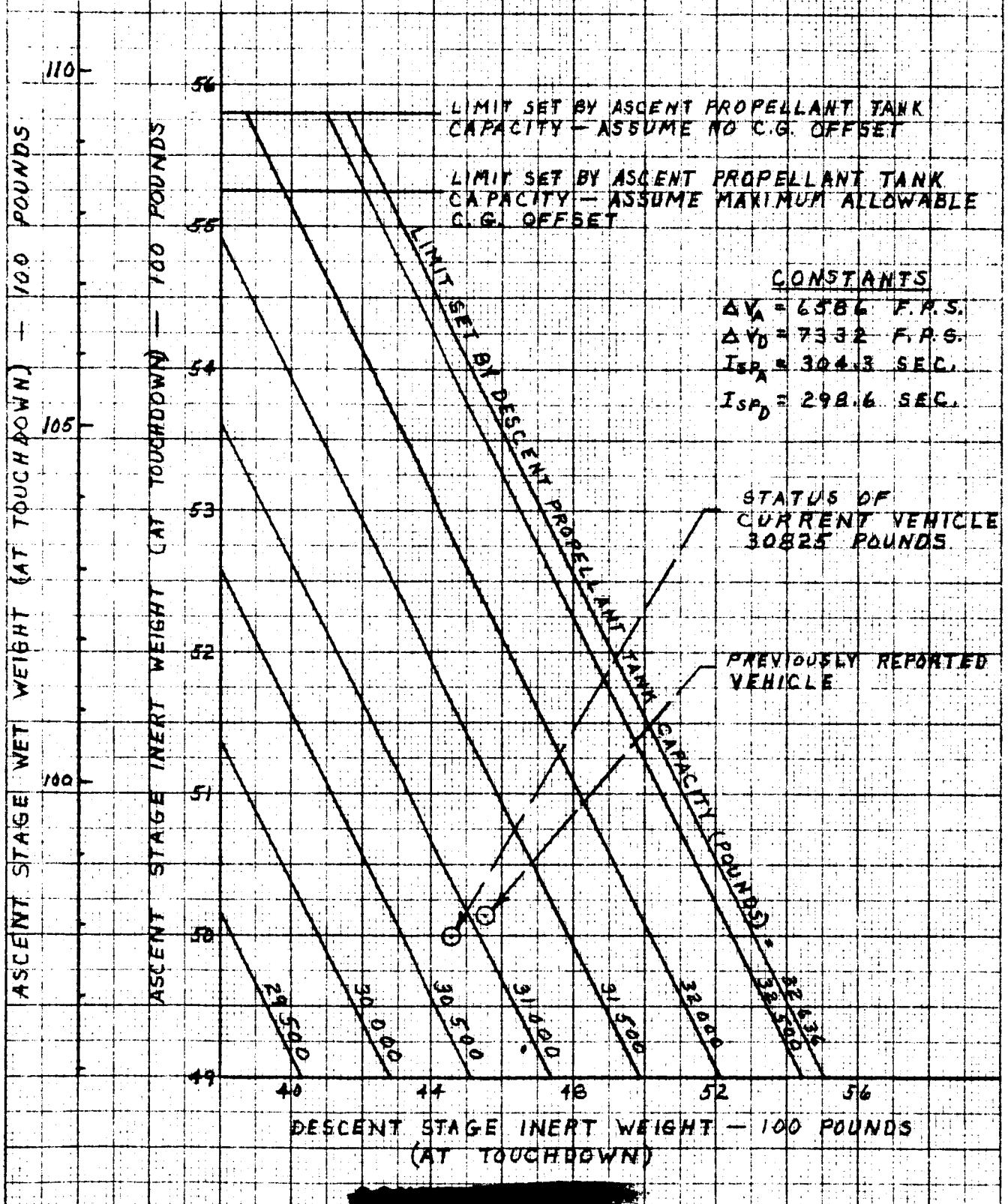

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FIGURE 2

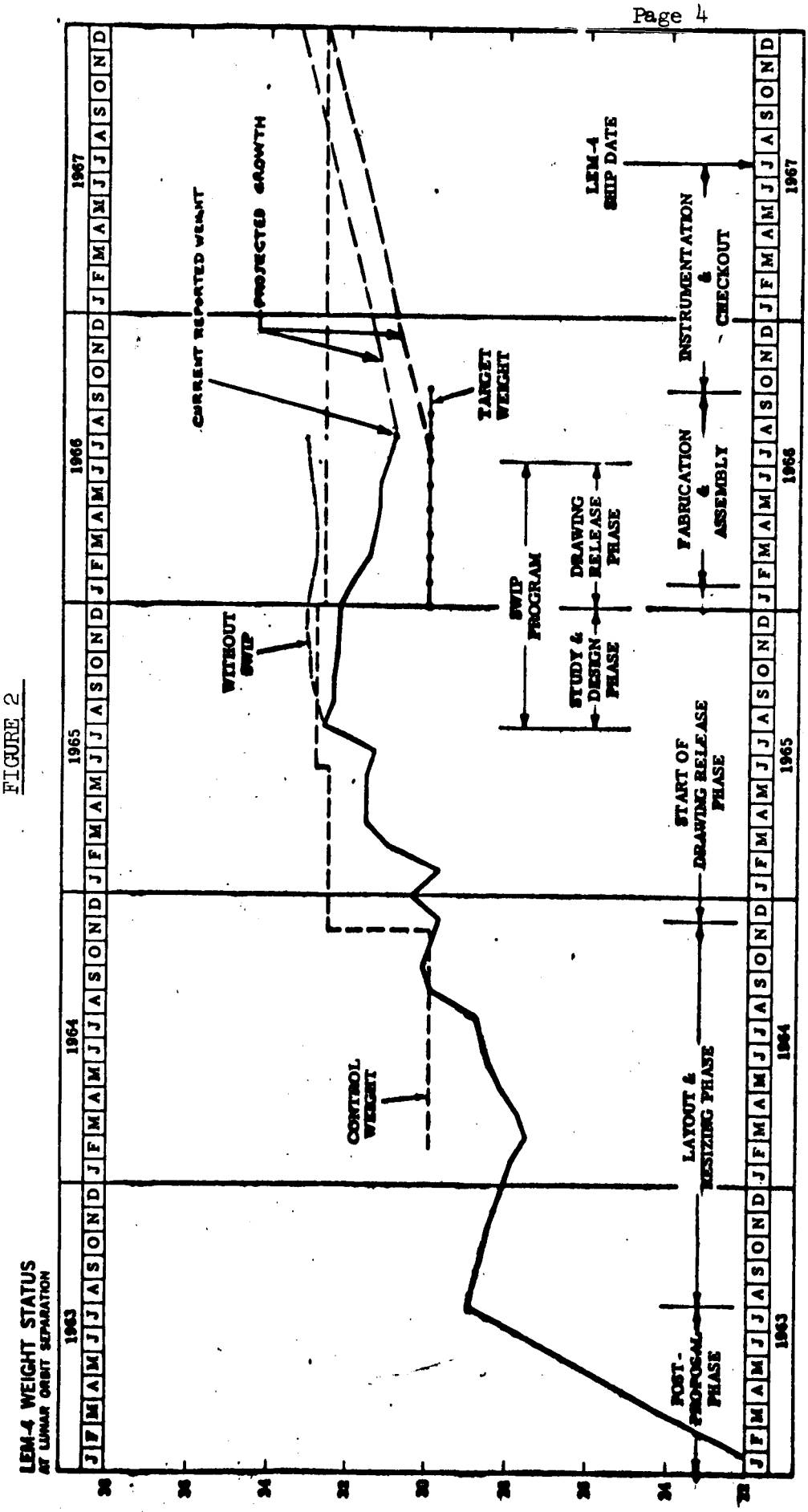

LEM-4 WEIGHT STATUS
AT LUNAR ORBIT SEPARATION
1963
1964
1965
1966
1967
CURRENT REPORTED WEIGHT
PROJECTED GROWTH
WITHOUT SWIP
CONTROL WEIGHT
TARGET WEIGHT
SWIP PROGRAM
STUDY & DESIGN PHASE
DRAWING RELEASE PHASE
LEM-4 SHIP DATE
INSTRUMENTATION & CHECKOUT
FABRICATION & ASSEMBLY
START OF DRAWING RELEASE PHASE
LAYOUT & RESIZING PHASE
POST-PROPOSAL PHASE
WEIGHT, 1000 lb

Table 1

LEM MASS PROPERTY HISTORY

MISSION PHASE	WEIGHT EARTH POUNDS	CENTER OF GRAVITY STATION INCHES X	CENTER OF GRAVITY DISTANCE FROM THRUST AXIS Y	CENTER OF GRAVITY DISTANCE FROM THRUST AXIS Z	MOMENTS OF INERTIA SLUG FT^2 I_{xx}	MOMENTS OF INERTIA SLUG FT^2 I_{yy}	MOMENTS OF INERTIA SLUG FT^2 I_{zz}	PRODUCTS OF INERTIA SLUG FT^2 I_{yz}	PRODUCTS OF INERTIA SLUG FT^2 I_{xz}	PRODUCTS OF INERTIA SLUG FT^2 I_{xy}
Translunar Injection	30313	182.6	-0.2	-0.6	20331	22987	23196	189	284	268
LEM/CSM Separation	30825	183.8	-0.1	0.2	21729	24220	24257	188	588	265
End Insertion to Hohman -Descent	30435	183.6	-0.1	0.2	21482	24022	24093	189	589	265
Begin Hover	15989	204.3	-0.3	0.5	12074	14789	16911	210	534	302
Lunar Touchdown	14223	212.9	-0.4	0.6	10934	11778	14127	212	518	312
Lunar Launch (lift-off)	9681	242.0	0.5	1.7	5958	3130	5388	-8	162	50
Concentric Sequence Initiation Maneuver	5153	256.8	1.0	3.4	2819	2566	1742	-10	107	35
Final Hard Docking LEM/CSM	4858	256.1	1.0	3.6	2680	2482	1548	2	110	35
Completion of Crew Transfer	4248	256.5	1.1	-0.7	2423	2249	1420	8	136	40

Table 2
SUMMARY OF LEM WEIGHT REPORTING MISSION

MISSION PHASE	ELAPSED TIME FROM EARTH LAUNCH		REPORTING MISSION (Day Landing) For Loading Expendables			
Description	Hours	Minutes	Hours	Minutes		
Prelaunch (Launch Vehicle Fueling)	-10	0			Pre-Separation Period	Dormant Period
			10			
Launch	0	0				
				12		
Earth Parking Orbit		12				
			2	49		
Translunar Injection	3	1				
				5		
Translunar Coast- Prior to Transposition	3	6				
				15		
-During Transposition	3	21				
				30		
-Subsequent to Transposition	3	51				
			60	24		
Lunar Orbit - Insertion	64	15				
				6		
-Coast Prior to Separation	64	21				
			1	26		
-Checkout	65	47				
			2	17		
LEM Separation and Insertion to Descent Transfer Orbit	68	4			Descent*	Active Period
				20		
Coast in Descent Transfer Orbit	68	24				
				58		
Powered Descent (& Hover)	69	22				
				10		
Lunar Staytime (Touchdown)	69	32				
			34	45		
Lunar Lift Off - Powered Ascent	104	17			Ascent**	
				34		
Parking Orbit Contingency ***						
Concentric Sequence Initiation Maneuver	104	51				
			2	8		
Final Hard Docking LEM/CSM	106	59				
				10		
Crew Transferred	107	9				
Dormant LEM Time			75	47		
Active LEM Time			41	22		
Post-Separation LEM Time			(39)	(5)		
			117	9		

* Descent Period - 1 Hour 28 Minutes

** Ascent Period - 2 Hours 52 Minutes

*** The Design Reference Mission (DRM) does not appear to have any Parking Orbit Contg..

Table 3

LEM WEIGHT BY STAGES AT EARTH LAUNCH AND LUNAR ORBIT SEPARATION - DISTRIBUTION OF THE INERT WEIGHT BY PERCENTAGE

		WEIGHT			PERCENTAGE			
		ASCENT	DESCENT	TOTAL	EST'D	LAYOUT	CALC'D	ACTUAL
1.0	Structure	(1126.5)	(1028.8)	(2155.3)	14.5	20.0	55.7	9.8
	-Ascent	1126.5	--	1126.5	2.6	27.0	47.1	23.3
	-Descent	--	1028.8	1028.8	21.5	10.1	61.1	7.3
2.0	Stabilization and Control	77.1	13.7	90.8	--	--	100.0	--
3.0	Navigation and Guidance	74.6	38.1	112.7	--	.4	99.6	--
4.0	Crew Provisions	74.1	1.1	75.2	37.9	3.3	58.8	--
5.0	Environmental Control	283.4	107.5	390.9	4.0	--	55.8	40.2
6.0	Landing Gear	--	469.2	469.2	4.5	2.5	72.3	20.7
7.0	Instrumentation	128.5	6.7	135.2	15.5	--	84.5	--
8.0	Electrical Power Supply	746.8	642.2	1389.0	31.2	.4	14.0	54.4
9.0	Propulsion	515.8	1095.7	1611.5	3.9	2.0	45.5	48.6
10.0	Reaction Control	280.9	--	280.9	--	--	27.2	72.8
11.0	Communications	110.8	18.8	129.6	20.2	--	79.0	.8
12.0	Controls and Displays	195.4	2.5	197.9	24.6	2.9	45.4	27.1
13.0	Explosive Devices	11.5	39.6	51.1	48.3	--	26.3	25.4
	Hardware- Sub-Total	3625.4	3463.9	7089.3	13.1	6.6	46.4	33.9
14.0	Government Furnished Equipment	454.1	223.6	677.7	79.0	--	12.1	8.9
15.0	Liquids and Gases - Excludes Propellant	119.8	324.8	444.6	66.0	--	34.0	--
17.0	Propellants - Excludes Delta - V	430.8	473.8	904.6				
	Inert- Sub-Total	4630.1	4486.1	9116.2				
16.0	Propellants - Delta - V	(4784.4)	(16412.2)	(21196.6)				
	-Propulsion	4515.4	16412.2	20927.6				
	-Reaction Control	269.0	--	269.0				
	Total - Earth Launch	9414.5	20898.3	30312.8				
5.0	Environmental Control	-1.0	--	-1.0				
14.0	Government Furnished Equipment	+531.5	--	+531.5				
15.0	Liquids and Gases - Excludes Prop.	+6.9	-16.7	-9.8				
17.0	Propellants - Check-out and Attitude	-8.6	--	-8.6				
	Total - Separation	9943.3	20881.6	30824.9				

Table 4

LEM CURRENT WEIGHT MISSION HISTORY BY STAGES

MISSION PHASE AND CONSUMABLE DESCRIPTION	ASCENT STAGE DRY WEIGHT (LBS)	ASCENT STAGE ΔV-PROPELL. WEIGHT (LBS)	DESCENT STAGE DRY WEIGHT (LBS)	DESCENT STAGE ΔV-PROPELL. WEIGHT (LBS)	TOTAL WEIGHT (LBS)
EARTH LAUNCH AND TRANSLUNAR INJECTION	4630.1	4784.4	4486.1	16412.2	30312.8
ECS-Umbilical Hardware	-1.0				
GFE-Electrical Umbilical	-3.1				
-Crew	+352.0				
-Crew Equipment	+174.4				
-Television Camera	+8.2				
Liquids and Gases -Oxygen	+6.9		-1.5		
-Water			-15.2		
Propellant - Checkout	-4.4				
- Attitude	-4.2				
SEPARATION	5158.9	4784.4	4469.4	16412.2	30824.9
Liquids and Gases - Oxygen			- .5		
-Water			-9.4		
Propellant -Main ΔV				-16412.2	
-Reaction Control ΔV		-19.5			
-Attitude	-159.9				
LUNAR TOUCHDOWN	4999.0	4764.9	4459.5		14223.4
CFE-Hardware	-7.9		-3463.9		
CFE-Crew Equipment	-67.7		-20.6		
-Scientific Equipment			-203.0		
Liquids and Gases -Oxygen	- .2		-44.5		
-Water	- 3.1		-203.9		
-Helium			-49.2		
-Nitrogen			- .6		
Propellant - Unusable			-473.8		
-Checkout	- 4.4				
LUNAR LIFT - OFF	4915.7	4764.9			9680.6
Liquids and Gases - Oxygen	- .8				
-Water	- 11.5				
Propellant -Main ΔV		-4515.4			
-Reaction Control ΔV		-249.5			
-Attitude	- 45.9				
BURNOUT (DOCKING)	4857.5				4857.5

LEM
WEIGHT STATEMENT

CODE	ITEM	7/1/66 WEIGHT AT SEPARATION	CURRENT WEIGHT STATUS: BURN OUT	CONS'D ON ASCENT	JET. ON LURAIN	CONS'D ON DESCENT	TOTAL SEPARATION	X-LUNAR EXPEND-ABLES	EARTH LAUNCH TOTAL
1.0	Structure	2271.2	1126.5		1028.8		2155.3		2155.3
2.0	Stabilization and Control	91.5	77.1		13.7		90.8		90.8
3.0	Navigation and Guidance	111.4	74.6		38.1		112.7		112.7
4.0	Crew Provisions	78.3	74.1		1.1		75.2		75.2
5.0	Environmental Control	390.2	274.8		115.1		389.9	1.0	390.9
6.0	Landing Gear	469.6			469.2		469.2		469.2
7.0	Instrumentation	135.3	128.5		6.7		135.2		135.2
8.0	Electrical Power	1388.0	746.8		642.2		1389.0		1389.0
9.0	Propulsion	1610.2	515.8		1095.7		1611.5		1611.
10.0	Reaction Control	278.9	280.9				280.9		280.9
11.0	Communications	128.6	110.5		19.1		129.6		129.6
12.0	Controls and Displays	194.6	195.4		2.5		197.9		197.9
13.0	Explosive Devices	48.1	11.5		39.6		51.1		51.1
Note:	Contractor Furnished Hardware	7195.9	3616.5		3471.8		7088.3	1.0	7089.3

LEM
WEIGHT STATEMENT

CODE	ITEM	7/1/66 WEIGHT AT SEPARATION	CURRENT WEIGHT STATUS: BURN OUT	CONS'D ON ASCENT	JET. ON LURAIN	CONS'D ON DESCENT	TOTAL SEPARATION	X-LUNAR EXPEND-ABLES	EARTH LAUNCH TOTAL
14.0	Government Furnished Equipment	1209.2	917.9		291.3		1209.2	-531.5	677.7
15.0	Liquids and Gases	435.3	111.1	12.3	301.5	9.9	434.8	9.8	444.6
16.0	Propellant - Delta V	(21350.9)		(4764.9)		(16431.7)	(21196.6)		(21196.6)
	-Main	21081.0		4515.4		16412.2	20927.6		20927.6
	-RCS	269.9		249.5		19.5	269.0		269.0
17.0	Propellant - Non Delta - V	(896.0)	(212.0)	(45.9)	(478.2)	(159.9)	(896.0)	(8.6)	(904.6)
	-Unusable	662.1	188.3		473.8		662.1		662.1
	-Attitude and Checkout	233.9	23.7	45.9	4.4	159.9	233.9	8.6	242.5
		31087.3	4857.5	4823.1	4542.8	16601.5	30824.9	-512.1	30312.8
	Burnout Weight	4872.1	4857.5 lbs.						
	Lift-off Weight	9709.5		9680.6 lbs.					
	Touchdown Weight	14345.8			14223.4 lbs.				
	Separation Weight	31087.3					30824.9 lbs.		
	Earth Launch Weight	30575.2							30312.8 lbs.

Table 2

LEM WEIGHT COMPARISON
AT SEPARATION BY STAGES

Subsystem	Item	7/1/66 Weight	Current Weight	Delta Weight
A.	Ascent Stage Weight at Separation	9972.3	9943.3	-29.0
1.0	Structure	1140.1	1126.5	-13.6
2.0	Stabilization and Control	77.3	77.1	- .2
3.0	Navigation and Guidance	74.1	74.6	+ .5
4.0	Crew Provisions	78.3	74.1	- 4.2
5.0	Environmental Control	282.7	282.4	- .3
6.0	Landing Gear	--	--	--
7.0	Instrumentation	127.8	128.5	+ .7
8.0	Electrical Power Supply	747.3	746.8	- .5
9.0	Propulsion System	515.6	515.8	+ .2
10.0	Reaction Control	278.9	280.9	+ 2.0
11.0	Communications	110.8	110.8	0
12.0	Controls and Displays	194.6	195.4	+ .8
13.0	Explosive Devices	11.5	11.5	0
14.0	Government Furnished Equipment	985.6	985.6	0
15.0	Liquids & Gases - Excludes Propellant	126.7	126.7	0
16.0	Propellant - Delta -V	(4798.8)	(4784.4)	(-14.4)
	-Main	4528.9	4515.4	-13.5
	-Reaction Control	269.9	269.0	- .9
17.0	Propellant - Non-Delta -V	(422.2)	(422.2)	(0)
	-Main (130.3# Unusable)	140.4	140.4	0
	-Reaction Control (58.0# Unusable)	281.8	281.8	0
B.	Descent Stage Weight at Separation	21115.0	20881.6	-233.4
1.0	Structure	1131.1	1028.8	-102.3
2.0	Stabilization and Control	14.2	13.7	- .5
3.0	Navigation and Guidance	37.3	38.1	+ .8
4.0	Crew Provisions	--	1.1	+1.1
5.0	Environmental Control	107.5	107.5	0
6.0	Landing Gear	469.6	469.2	- .4
7.0	Instrumentation	7.5	6.7	- .8
8.0	Electrical Power Supply	640.7	642.2	+ 1.5
9.0	Propulsion System	1094.6	1095.7	+ 1.1
11.0	Communications	17.8	18.8	+ 1.0
12.0	Controls and Displays	--	2.5	+ 2.5
13.0	Explosive Devices	36.6	39.6	+ 3.0
14.0	Government Furnished Equipment	223.6	223.6	0
15.0	Liquids and Gases - Excludes Propellant	308.6	308.1	- .5
16.0	Propellant - Delta -V -Main	16552.1	16412.2	-139.9
17.0	Propellant - Propulsion (Unusable)	473.8	473.8	0
	Total Separation Weight (A & B)	31087.3	30824.9	-262.4

DISCUSSION OF WEIGHT CHANGES BY RESPONSIBILITY AND STAGES SINCE LAST REPORT - AT SEPARATION

	Inert* Wt. Chgs. By Stages		Effective Weight By Responsibility	
	Ascent (-20.5)	Descent (-93.1)	GAEC (-286.3)	NASA
Super Weight Improvement Program				
The current effects of the Super Weight Improvement Program (SWIP) for this reporting period are decreases of 93.1 pounds in the descent stage and 20.5 pounds in the ascent stage. A more detailed breakdown of the SWIP changes are as follows:				
Scrape effort on 35 Ascent Structure drawings, 42 Descent Structure Drawings and 25 Crew Provision drawings indicate weight reductions of 17.0 pounds, 4.5 pounds and 4.8 pounds respectively.				
1.0 Structure	-17.0	- 5.8	-84.3	
4.0 Crew Provisions	- 2.9		-12.2	
12.0 Controls and Displays	- .6		- 2.5	
Redesign descent thermal shield to a combination inconel and nickel foil, and inconel mesh, and H-film configuration. Incorporation of this descent stage portion completes SWIP change LWSS 280A-34.				
1.0 Structure		-87.3	-187.3	
Relocate Descent Batteries		(+14.3)	(+ 30.7)	
Relocated two descent batteries to alleviate a c.g. problem. Any reduction in unuseable propellant due to reducing the head differential between the Descent Propellant Tanks will appear in a subsequent report.				
1.0 Structure		+11.6	+ 24.9	
8.0 Electric Power Supply		+ 2.7	+ 5.8	

* Inert weight excludes ΔV propellant.

DISCUSSION OF WEIGHT CHANGES BY RESPONSIBILITY AND STAGES SINCE LAST REPORT - AT SEPARATION -Cont.

	Inert* Wt. Chgs. By Stages		Effective Weight By Responsibility	
	Ascent	Descent	GAEC	NASA
	(+ 2.7)	(- 1.4)	(+ 8.3)	
Miscellaneous Vendor Weight Changes				
Weight changes of vendored items based on current reported weights are as follows:				
2.0 Stabilization and Control				
-Attitude Translational Control Assy	- .4		- 1.7	
-Abort Electronic Assembly	+ .2		+ .8	
-Descent Engine Control Assembly		- .7	- 1.5	
3.0 Navigation and Guidance				
-Rendezvous Radar Antenna Assembly	+ .5		+ 2.1	
-Landing Radar Antenna Assembly		+ .8	+ 1.7	
5.0 Environmental Control				
-Atmosphere Revitalization Components	- .2		- .8	
-Heat Transport Components	- .2		- .8	
-Oxygen Supply and Control Components	+ .1		+ .4	
7.0 Instrumentation				
-Signal Conditioner Electronic Assemblies	+ .8		+ 3.4	
-Pulse Code Modulation and Timing Electronics	+ .3		+ 1.3	
8.0 Electrical Power Supply				
-Circuit Breakers (146)	+ 2.0		+ 8.4	
-Batteries	- 3.4	- 1.2	-16.9	
9.0 Propulsion				
-Pressure Regulators	+ .2	- 1.0	- 1.3	
-Supercritical Helium Tank		+ 1.6	+ 3.4	
10.0 Reaction Control				
-Isolation Valves	+ 1.8		+ 7.6	
-Cluster Heaters	+ .2		+ .8	

* Inert weight excludes ΔV propellant.

DISCUSSION OF WEIGHT CHANGES BY RESPONSIBILITY AND STAGES SINCE LAST REPORT - AT SEPARATION - Cont.

	Inert* Wt. Chgs. By Stage		Effective Weight By Responsibility	
	Ascent	Descent	GAEC	NASA
Miscellaneous Vendor Weight Changes - Cont.				
12.0 Controls and Displays				
-Attitude Range Indicators	+ .8		+ 3.4	
13.0 Explosive Devices				
-Explosive Bolts		- .4	- .9	
15.0 Liquids and Gases				
-Helium		- .5	- 1.1	
Miscellaneous Weight Changes	(+ 3.2)	(- 13.3)	(-15.1)	
Continuing review and updating of the vehicle structure and the landing gear structure indicates a 5.6 pound increase in the ascent structure, a 19.1 pound decrease in the descent structure, and a .4 pound decrease in the landing gear.				
1.0 Structure	+ 5.6	- 19.1	-17.3	
6.0 Landing Gear		- .4	- .9	
Equipment supports are recoded to the equipment code and the weight updated according to current information.				
1.0 Structure		- 2.7	- 5.8	
2.0 Stabilization and Control		+ .2	+ .4	
4.0 Crew Provisions		+ 1.1	+ 2.4	
11.0 Communications		+ 1.0	+ 2.1	
13.0 Explosive Devices		+ .6	+ 1.3	
Redesign of Crew Provision drawings and updating of weights indicate the following weight changes.				
1.0 Structure	- 1.5		- 6.3	
4.0 Crew Provisions	- 1.3		- 5.5	

* Inert weight excludes ΔV propellant.

DISCUSSION OF WEIGHT CHANGES BY RESPONSIBILITY AND STAGES SINCE LAST REPORT - AT SEPARATION - Cont.

		Inert* Wt. Chgs. By Stage		Effective Weight By Responsibility	
		Ascent	Descent	GAEC	NASA
Miscellaneous Weight Changes - Cont.					
Additional Critical Design Review (CDR) weight changes are included in this report. Items affected are the addition of a pressure sensor and a control assembly, and local reinforcement of Descent shielding due to RCS thruster impingement.					
1.0	Structure - Descent Shielding		+ 1.0	+ 2.1	
9.0	Propulsion - Redundant Pressure Sensor		+ .5	+ 1.1	
12.0	Controls and Display - Control Assembly		+ 2.5	+ 5.4	
Other changes include addition of new items and deletion of duplicated items. A time delay is required to keep the propellant from freezing in the helium heat exchanger. A fuse box and toggle switch, previously omitted, are added. Previously duplicated stiffener and transducers are deleted. The actual weight of early models of the translation controllers are incorporated.					
1.0	Structure - Stiffener	- .7		- 3.0	
7.0	Instrumentation - Transducers (6)	- .4	- .8	- 3.4	
8.0	Electrical Power Supply - Fuse Box	+ .9		+ 3.8	
12.0	Controls and Displays - Switch	+ .2		+ .8	
	-Translation Controllers (2)	+ .4		+ 1.7	
13.0	Explosive Devices		+ 2.8	+ 6.0	
TOTAL INERT WEIGHT CHANGES		-14.6	- 93.5		
TOTAL EFFECTIVE WEIGHT CHANGES BY RESPONSIBILITY				-262.4	

TOTAL REPORTED WEIGHT CHANGES = -262.4 pounds

* Inert weight excludes Δ V propellant.

Pending Changes

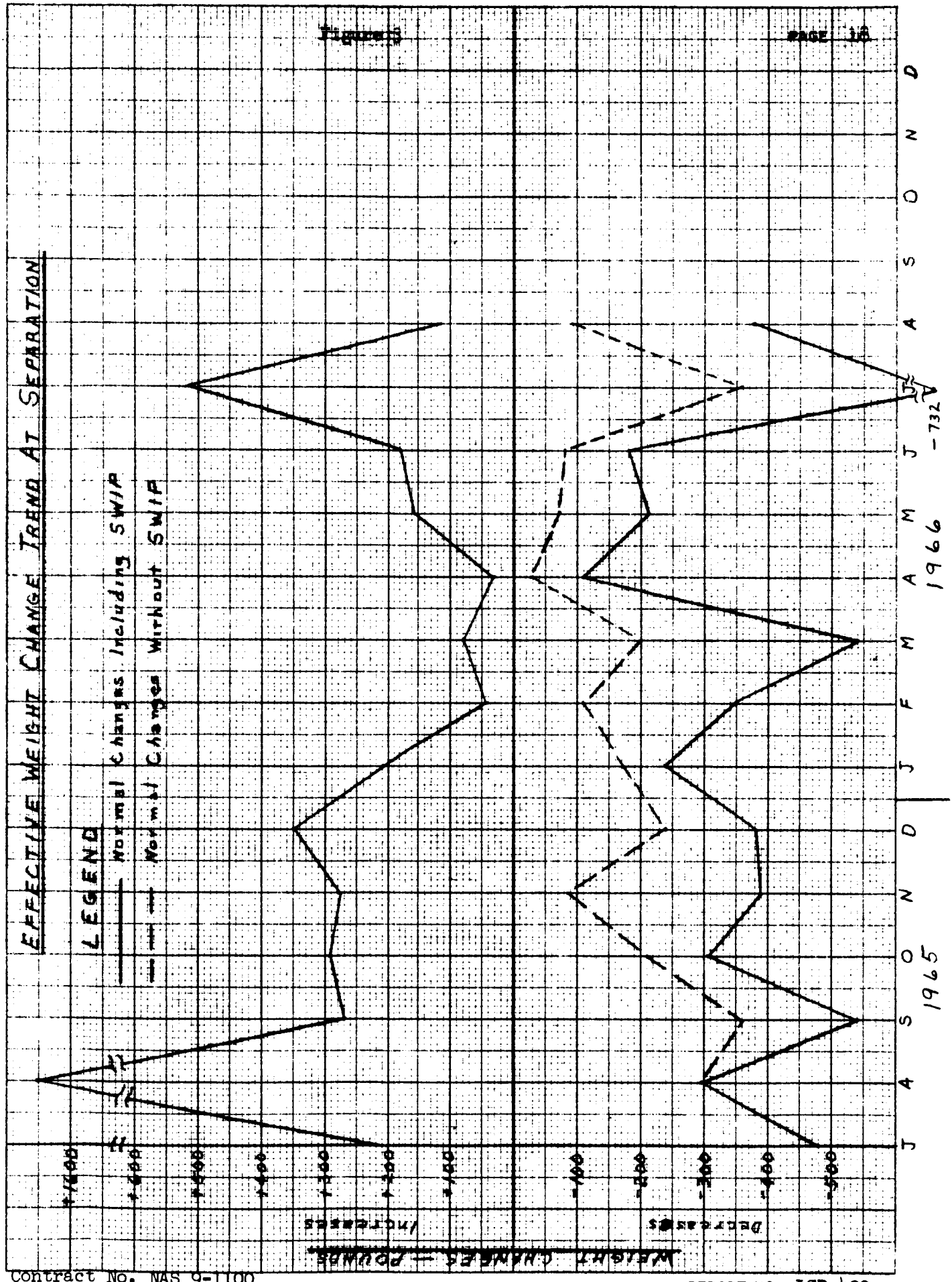
		Estimated Weight Increment		
		Ascent (Inert*)	Descent (Inert*)	Separation (Effective)
1.	Incorporate the stowage provisions for additional Government Furnished Equipment.			
	RTG Fuel Cask	-	+3.0	+6.4
	Miscellaneous	+2.1	-	+8.8
2.	Eliminate Landing Gear Thermal Paint from the Primary and Secondary Struts since the paint does not appear to be an effective regulator of the honeycomb cartridge temperature. Wrapping NRC-2 around the struts is a solution currently under study.		+2.1	+4.5
3.	Reduce battery cell cases to .050 in. thickness - SWIP change LWSS 390A-53.	-4.0	-8.0	-34.1
4.	Resize LUT dead-face relay for LEM 4 and subsequent due to lower power requirements - SWIP change LWSS 390A-17.	-1.0		-4.2
5.	Review and revise the unusable propellant philosophy.	+1.3	-98.8	-206.5
6.	Add ambient helium pre-pressurization tank and associated controls to Descent Propulsion System to insure helium flow if propellant system is not fully pressurized. (Partially incorporated.)	(+ .4)	(+5.0)	(+12.4)
	Electrical Power	+ .4	+2.0	+6.0
	Structure	0	+3.0	+6.4
7.	Cant Ascent Engine to reduce lateral distance between Engine thrust vector and vehicle's center of gravity, and thus lessen the RCS Control requirements.	(+5.7)		(+24.1)
	Structure	+3.0		+12.7
	Trapped Propellant	+2.7		+11.4

* Inert weight excludes ΔV propellant.

Pending Changes - Cont.

		Estimated Weight Increment		
		Ascent (Inert*)	Descent (Inert*)	Separation (Effective)
8.	Add hat sections and screens to descent and ascent propellant tanks to insure propellant remains in the main feed lines during "0" G operation and prior to Engine Start. (Partially incorporated.)	+4.2	+13.6	+46.9
9.	Incorporation of the chits, submitted and approved for Critical Design Review (CDR) , reflect the following weight changes:			
	Controls and Displays	+2.1	0	+ 8.9
	Electro-Explosive Devices	+10.5	-9.5	+24.0
10.	Cover the Landing Gear Pads with ablative material to protect the pads from the high temperatures, that are expected to be encountered during the landing phase of the mission.		+8.4	+18.0
11.	Reduce the Descent Phase ΔV requirements by 232 fps. to offset the Descent Engine's degradation in I_{sp}.	--	--	-390.0
12.0	Add optical alignment sight and the mounting provisions to permit alignment through the commander's forward and overhead windows.	+2.6	--	+11.0
13.0	Incorporate local vertical functions into the attitude indicator.	+3.0	--	+12.7

* Inert weight excludes ΔV propellant.


EFFECTIVE WEIGHT CHANGE TREND AT SEPARATION
LEGEND
Normal Changes Including SWIP
Normal Changes Without SWIP
WEIGHT CHANGES — POUNDS
INCREASES
DECREASES
+1000
+900
+800
+700
+600
+500
+400
+300
+200
+100
-100
-200
-300
-400
-500
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LEM-1 STATUS

WEIGHT COMPARISONS BY STAGES AT EARTH LAUNCH

		Weight		
		7/1/66	Current	Delta
A.	Ascent Stage Inert Weight at E. L.	5028.7	4936.2	-92.5
1.0	Structure	1340.9	1359.2	+18.3
2.0	Stabilization and Control	77.3	77.1	- .2
3.0	Navigation and Guidance	74.1	74.6	+ .5
4.0	Crew Provisions	82.5	78.3	- 4.2
5.0	Environmental Control	276.2	275.9	- .3
7.0	Instrumentation	126.2	126.9	+ .7
8.0	Electrical Power Supply	834.1	833.6	- .5
9.0	Propulsion System	521.9	522.1	+ .2
10.0	Reaction Control	294.4	296.4	+ 2.0
11.0	Communications	109.0	109.0	0
12.0	Controls and Displays	191.3	192.3	+ 1.0
13.0	Explosive Devices	14.9	14.9	0
	Hardware-Sub-Total	(3942.8)	(3960.3)	(+17.5)
14.0	Government Furnished Equipment	266.4	266.4	0
15.0	Liquids & Gases - Excludes Propellant	118.3	118.3	0
17.0	Propellant - Unusable	188.3	188.3	0
19.0	R & D Equipment & Misc.	512.9	402.9	-110.0
B.	Descent Stage Inert Weight at E. L.	4601.3	4371.5	-229.8
1.0	Structure	1202.5	1114.1	-88.4
2.0	Stabilization and Control	14.2	13.7	- .5
3.0	Navigation and Guidance	37.3	38.1	+ .8
4.0	Crew Provisions	--	1.1	+ 1.1
5.0	Environmental Control	107.5	107.5	0
6.0	Landing Gear	470.4	470.0	- .4
7.0	Instrumentation	5.9	5.1	- .8
8.0	Electrical Power Supply	649.3	650.8	+ 1.5
9.0	Propulsion System	1117.0	1106.4	-10.6
11.0	Communications	2.3	3.3	+ 1.0
13.0	Explosive Devices	36.8	39.9	+ 3.1
	Hardware-Sub-Total	(3643.2)	(3550.0)	(-93.2)
14.0	Government Furnished Equipment	--	--	--
15.0	Liquids and Gases - Excludes Propellant	323.8	322.2	-1.6
17.0	Propellant - Propulsion (Unusable)	473.8	473.8	0
19.0	R & D Equipment & Misc.	160.5	25.5	-135.0
	TOTAL INERT WEIGHT AT E. L. (A & B)	9630.0	9307.7	-322.3

LEM-1 Unmanned Condition	Control Weight	Current Weight
Ascent stage inert at Earth Launch	5540	4936
Descent stage inert at Earth Launch	5200	4372
RCS Propellant	550*	540
Ascent Main Propellant	5015*	5070
Descent Main Propellant	17000*	17513
Total Vehicle - Earth Launch	33305**	32431**

* Ref. 4 indicates that the propellant requirements are approximate.

** Design Weight at Earth Launch is 32,000 pounds.

LEM-2 STATUS

WEIGHT COMPARISONS BY STAGES AT EARTH LAUNCH

		Weight		
		7/1/66	Current	Delta
A.	Ascent Stage Inert Weight at E. L.	5148.7	5056.4	-92.3
1.0	Structure	1345.2	1363.5	+18.3
2.0	Stabilization and Control	77.3	77.1	- .2
3.0	Navigation and Guidance	74.1	74.6	+ .5
4.0	Crew Provisions	82.5	78.3	- 4.2
5.0	Environmental Control	283.8	283.5	- .3
7.0	Instrumentation	127.4	128.1	+ .7
8.0	Electrical Power Supply	834.1	833.6	- .5
9.0	Propulsion System	521.9	522.1	+ .2
10.0	Reaction Control	294.4	296.4	+ 2.0
11.0	Communications	109.0	109.0	0
12.0	Controls and Displays	191.3	192.5	+ 1.2
13.0	Explosive Devices	14.9	14.9	0
	Hardware-Sub-Total	(3955.9)	(3973.6)	(+17.7)
14.0	Government Furnished Equipment	387.3	387.3	0
15.0	Liquids & Gases - Excludes Propellant	118.3	118.3	0
17.0	Propellant - Unusable	188.3	188.3	0
19.0	R & D Equipment & Misc.	498.9	388.9	-110.0
B.	Descent Stage Inert Weight at E. L.	4363.8	4263.0	-100.8
1.0	Structure	1124.5	1014.9	-109.6
2.0	Stabilization and Control	14.2	13.7	- .5
3.0	Navigation and Guidance	37.3	38.1	+ .8
4.0	Crew Provisions	--	1.1	+ 1.1
5.0	Environmental Control	107.5	107.5	0
6.0	Landing Gear	470.4	470.0	- .4
7.0	Instrumentation	7.1	6.3	- .8
8.0	Electrical Power Supply	649.3	650.8	+ 1.5
9.0	Propulsion System	1098.6	1099.7	+ 1.1
11.0	Communications	4.7	5.7	+ 1.0
12.0	Controls and Displays	--	2.5	+ 2.5
13.0	Explosive Devices	36.8	39.8	+ 3.0
	Hardware-Sub-Total	(3550.4)	(3450.1)	(-100.3)
14.0	Government Furnished Equipment	--	--	--
15.0	Liquids and Gases - Excludes Propellant	323.8	323.3	- .5
17.0	Propellant - Propulsion (Unusable)	473.8	473.8	0
19.0	R & D Equipment & Misc.	15.8	15.8	0
	TOTAL INERT WEIGHT AT E. L. (A & B)	9512.5	9319.4	-193.1

LEM-2 Manned Condition	Proposed Control Weight	Current Weight
Ascent Stage inert at Earth Launch	5310	5056.4
Descent Stage inert at Earth Launch	4680	4263.0
RCS Propellant	540*	540.0
Ascent Main Propellant	5090*	5070.0
Descent Main Propellant	17355*	17513.0
Total Vehicle - Earth Launch	32975**	32442.4**

* Propellant requirements are approximate.

**Design Weight at Earth Launch is 32,000 pounds.

LEM-3 STATUS

WEIGHT COMPARISONS BY STAGES AT EARTH LAUNCH

		Weight		
		7/1/66	Current	Delta
A.	Ascent Stage Inert Weight at E. L.	4833.5	4833.6	+ .1
1.0	Structure	1138.3	1139.4	+ 1.1
2.0	Stabilization and Control	77.3	77.1	- .2
3.0	Navigation and Guidance	74.1	74.6	+ .5
4.0	Crew Provisions	79.5	75.3	- 4.2
5.0	Environmental Control	284.0	283.7	- .3
7.0	Instrumentation	127.8	128.5	+ .7
8.0	Electrical Power Supply	839.8	839.3	- .5
9.0	Propulsion System	522.2	522.4	+ .2
10.0	Reaction Control	278.9	280.9	+ 2.0
11.0	Communications	109.0	109.0	0
12.0	Controls and Displays	194.6	195.4	+ .8
13.0	Explosive Devices	14.9	14.9	0
	Hardware-Sub-Total	(3740.4)	(3740.5)	(+ .1)
14.0	Government Furnished Equipment	396.1	396.1	0
15.0	Liquids & Gases - Excludes Propellant	119.8	119.8	0
17.0	Propellant - Unusable	188.3	188.3	0
19.0	R & D Equipment & Misc.	388.9	388.9	0
B.	Descent Stage Inert Weight at E. L.	4395.5	4297.9	-97.6
1.0	Structure	1130.5	1024.1	-106.4
2.0	Stabilization and Control	14.2	13.7	- .5
3.0	Navigation and Guidance	37.3	38.1	+ .8
4.0	Crew Provisions	--	1.1	+ 1.1
5.0	Environmental Control	107.5	107.5	0
6.0	Landing Gear	470.4	470.0	- .4
7.0	Instrumentation	7.5	6.7	- .8
8.0	Electrical Power Supply	652.5	654.0	+ 1.5
9.0	Propulsion System	1098.6	1099.7	+ 1.1
11.0	Communications	4.7	5.7	+ 1.0
12.0	Controls and Displays	--	2.5	+ 2.5
13.0	Explosive Devices	36.8	39.8	+ 3.0
	Hardware-Sub-Total	(3560.0)	(3462.9)	(-97.1)
14.0	Government Furnished Equipment	20.6	20.6	0
15.0	Liquids and Gases - Excludes Propellant	325.3	324.8	- .5
17.0	Propellant - Propulsion (Unusable)	473.8	473.8	0
19.0	R & D Equipment & Misc.	15.8	15.8	0
	TOTAL INERT WEIGHT AT E. L. (A & B)	9229.0	9131.5	-97.5

LEM-3 Manned Condition	Proposed Control Weight	Current Weight
Ascent Stage inert at Earth Launch	5225	4833.6
Descent Stage inert at Earth Launch	4845	4297.9
RCS Propellant	540*	540.0
Ascent Main Propellant	5090*	5070.0
Descent Main Propellant	17585*	17513.0
Total Vehicle - Earth Launch	33285**	32254.5**

* Propellant requirements are approximate.

** Design Weight at Earth Launch is 32,000 pounds.

LIST OF REFERENCES

1. MSC letter PL2-13-64-571, dated 26 October 1964, "Contract NAS 9-1100, Transmittal of the Apollo Lunar Landing Design Reference Mission Trajectory."

2. MSC letter PP6-13-64-646, dated 20 November 1964, "Contract NAS 9-1100, LEM Weight Report."

3. MSC letter PL2-13-77/13-64-704, dated 14 December 1964, "Contract NAS 9-1100, Resolution of M-5 Mockup Review Chits 1-16 and 1-20."

4. MSC letter PS5/L231-13-65-1077, dated 9 December 1965, "Contract NAS 9-1100, Control Weights for LEM-1 (U)."

5. MSC letter PD3/L112-13-66-473, dated 24 June 1966, "Contract NAS 9-1100, GFE Weight Status Report."

6. MSC letter BG 54 66-183, dated 31 March 1966, "Contract NAS 9-1100, LEM Ascent and Rendezvous Concentric Flight Plan, Contract Change Authorization No. 211."

7. LED-490-23, dated 1 August 1965, "LEM Mass Property Report (U)."

8. LSR-490-34, dated 1 July 1966, "LEM Mass Property Report (U)."

9. LED-490-100 Revision B, Re-issued 15 February 1965, Allocation of Propellants and ΔV to Meet the ΔV Budget."

10. LAV-500-155, dated 6 July 1965, "Required ΔV for Abort Using the Ascent Engine."

11. LMO-310-247, dated 9 September 1965, "RCS Mission and Residual Propellant Requirements (U)."

12. LMO-490-165, dated 10 February 1965, "Ascent and Descent Main Propellant Allocation, Criteria and Assumptions."

13. LDW-340-54050, dated 24 May 1966, Inboard Profile.

14. LDW-280-10050, Revision E, dated 2 June 1965, "Geometry Ascent Stage -2 Tank" Drawing.

15. LDW-280-17000, Revision C, dated 17 June 1965, "General Arrangement Descent Stage" Drawing.

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APPENDIX A

SWIP ITEMS INCORPORATED IN WEIGHT REPORTS

A breakdown of the SWIP items incorporated to date in the LEM Weight Report is as follows:

LWSS Number	SWIP Items	Inert Weight By Stage Ascent	Inert Weight By Stage Descent	Effective Weight
	LED-490-25 Scrape Effort	-22.1		-93.0
	LED-490-26 Scrape Effort	-62.2	-12.5	-288.2
	LED-490-27 Scrape Effort	-13.9	- 8.8	-77.3
	LED-490-28 Scrape Effort	- 8.7	- 9.2	-56.1
	LED-490-29 Scrape Effort	- 4.6	-26.6	-76.0
	LED-490-30 Scrape Effort		- 8.8	-18.8
	LSR-490-31 Scrape Effort	- 5.5	-21.6	-69.1
	LSR-490-32 Scrape Effort	- 3.4	-17.0	-50.5
	LSR-490-33 Scrape Effort	-10.1	-21.4	-87.9
	LSR-490-34 Scrape Effort	- 1.1	- 9.1	-24.2
	LSR-490-35 Scrape Effort	-20.5	- 5.8	-99.0
270A-5(b)	Aluminum in lieu of Steel Diffusers.	- .7	- .6	- 4.2
270A-40	Scrape of Ascent Engine	- 2.9		-12.1
270A-46	Scrape of Descent Engine		-11.4	-24.3
270B-8	Remove redundancy of helium pressurization regulators.		- 4.0	- 8.5
270B-16	Delete baffles in LEM propellant tanks.	- 8.8	-38.0	-146.8
280A-20	Trim excess weight on cold plates in aft equipment bays.	- 1.6		- 6.7
280A-25	Redesign of Descent Stage engine actuator support structure.		- 5.4	-11.5
280A-53	Optimize Descent Propellant Tanks		-20.0	-42.6
280A-58	Re-arrange equipment on aft rack to eliminate ECA overhang and shorten wire runs.	- 1.0		- 4.2
280A-34	Redesign ascent thermal shield to a combination titanium or nickel foil configuration.	-36.8	-87.3	-342.4

APPENDIX A

SWIP ITEMS INCORPORATED IN WEIGHT REPORTS - Cont.

LWSS Number	SWIP Items	Inert Weight By Stage Ascent	Inert Weight By Stage Descent	Effective Weight
310B-1	Removal of redundant RCS pressurization components.	-13.1		-54.9
310B-2	Reduction in safety factor on RCS pressurization bottles from 2.0 to 1.5.	- 5.4		-22.6
310B-6	Delete latching solenoid valve from two RCS helium pressurization systems.	- 4.4		-18.5
320A-10	Replace compression deployment spring and surrounding can with curved leaf spring . (Descent Corner Post portion * This 1.6 pounds was reported as scrape effort in LED-490-29.)		- 1.6	- 3.4
340B-5	Reduce weight of GFE thermal/meteoroid garment.	-11.0		-46.3
360A-2	Optimize Data Storage Electronics Assembly.	- .1		- .4
360A-3	Optimize Caution and Warning Electronics Assembly.	- .5		- 2.1
360A-5	Optimize Signal Conditioner Electronics Assembly.	-10.6		-44.3
360B-2	Optimize Pulse Code Modulation and Timing Electronics Assembly.	-14.3		-59.9
370A-2	Eliminate stroke adjustment on gimbal drive actuator.		- .4	- .8
380A-11	Scrape of Steerable Antenna	- 3.8		-15.9
380B-2	Delete 80-foot cable for use of external TV. Also delete tripod and 10-inch cable.	- 1.3	- 3.0	-10.2
360A-10	Relocate Data Storage Electronic Assembly in cabin to eliminate cold plate.	- .3		- 1.3

APPENDIX A

SWIP ITEMS INCORPORATED IN WEIGHT REPORTS - Cont.

LWSS Number	SWIP Items	Inert Weight By Stage Ascent	Inert Weight By Stage Descent	Effective Weight
390A-21	Reduce functional requirements of lighting control assembly.	- 9.0		-37.6
390A-52	Optimize General Purpose Inverter	- .8		- 3.3
390B-2	Single Wire Electrical System using LEM Structure as ground.	-14.8		-62.0
390B-12 (Phase 2)	Eliminate automatic switchover circuitry for ECS glycol pumps.	- 1.5		- 6.3
510A-1	Replace thermal paint with etched surface treatment on thermal shields.	-24.0	-24.0	-150.0
520B-1	Landing Velocity envelope reduction to: 10-7-4 Design.		-26.6	-56.7
540B-2	Eliminate Delta V indicator.	- 1.8		- 7.5
280A-37	Optimization and definization of the materials, gages, joint details, method of support and general arrangement of the base heat shield.		-90.5	-193.7
INCORPORATED SWIP CHANGES - Total Weight		-320.6	-366.3	-2341.1