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CONTRACT REQUIREMENTS	CONTRACT ITEM	MODEL	CONTRACT NO.	DATE
Exhibit E, Para. 5.2	Line Item 13.0	LEM	NAS 9-1100	1/14/63

TYPE II

Primary Code 713

REPORT

NO. LED-490-24

DATE: 1 September 1965

LEM MASS PROPERTY REPORT (U)

CODE 26512

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INTRODUCTION

This report contains the LEM Mass Properties Status as of August 20, 1965 for the Lunar Landed Vehicle. The total weight at Separation is 32388.3 pounds, which is 266.6 pounds lighter than that previously reported in LED-490-23, dated 1 August 1965.

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

A.	Ascent Stage inert * weight	-42#
B.	Ascent Stage propellant	-36#
C.	Descent Stage inert * weight	-48#
D.	Descent Stage propellant	-141#
	Total LEM Weight Change at Separation	-267#

A more detailed breakdown of the changes since the last report is included on page 11.

Changes included in this report do not yet reflect the progress of the GAEC weight improvement program, or SWIP. The progress of this effort will be summarized in the monthly reports. The resultant weight savings will be incorporated in the reported weight after implementation (i.e. when drawings are revised, or when changes are reported by Vendors). As such, some of the reported weight reductions will lag the SWIP progress report weight reductions.

A. LEM Weight Reduction Program (SWIP)

Scrape effort to date includes drawing review of 744 pounds of Ascent structure with an estimated weight saving of 108 pounds. Descent structure is also in review but the weight reduction estimate is not available at this date.

Requirements review and redesign effort have established a list of potential weight reductions. This list includes 62 items of GAEC responsibility and 19 which will require NASA approval if recommended for implementation. These 81 items represent approximately 1100 pounds of potential weight reductions.

* Inert weight includes all non-propulsion expendables.

INTRODUCTION - Cont.

B. Propellant requirements included in this report are based on the LEM Reference Mission. The reference mission requires more propellant than the critical abort mission which was defined in the previous report. The Δ V Budget used for the reference mission is:

Ascent	6586 fps
Descent	7332 fps

FIGURE 1

LEM ALLOWABLE STAGE WEIGHT APPORTIONMENT

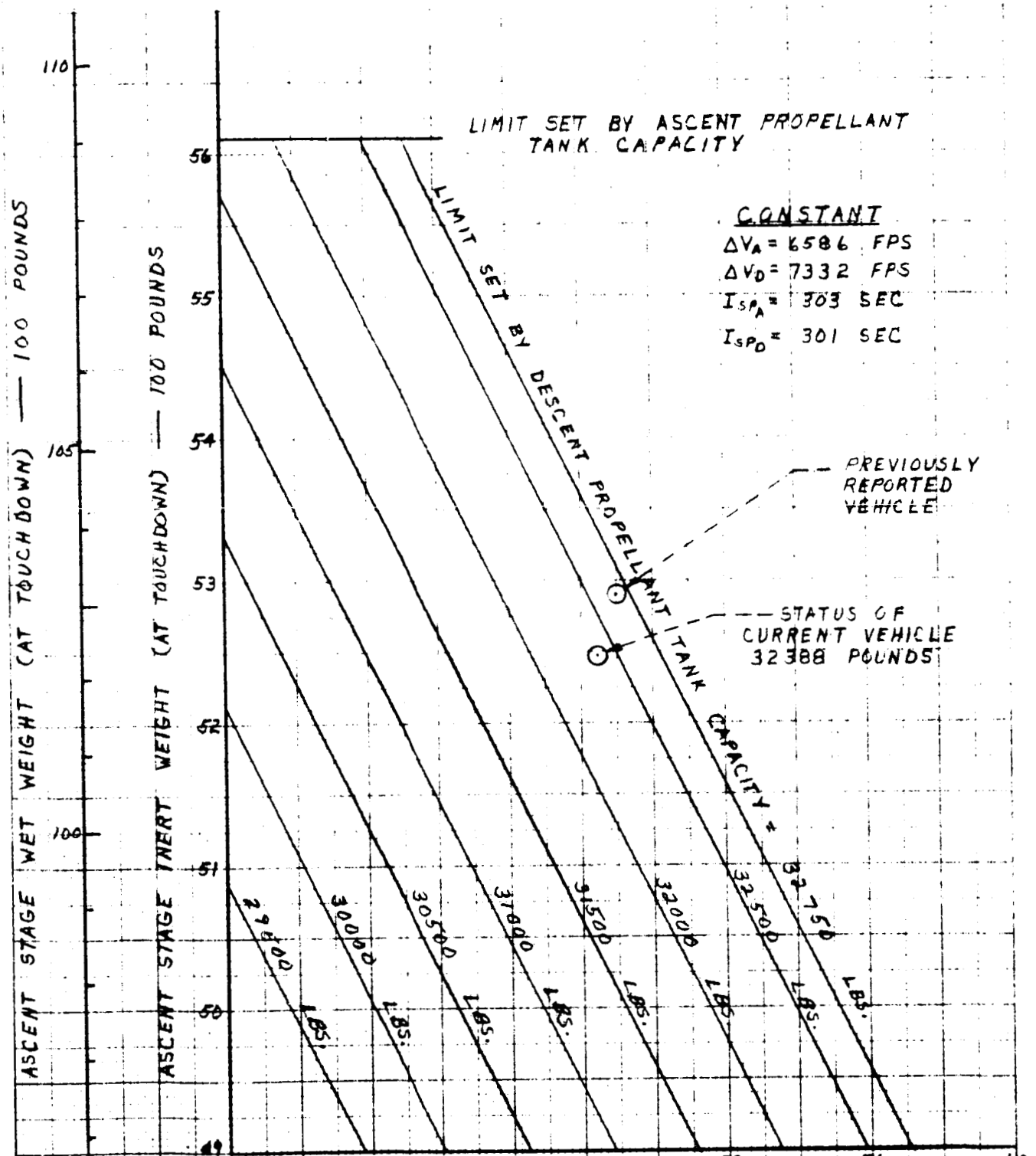

Table 1

LEM MASS PROPERTY HISTORY - CURRENT WEIGHT

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	31791	183.9	1.0	-0.6	21585	22954	28280	452	154	98
LEM/CSM Separation	32388	185.3	1.0	0.2	23138	24403	29508	440	485	114
End Insertion to Hohman -Descent	31939	185.4	1.1	0.2	22845	23902	28930	430	473	101
Begin Hover	16889	204.8	2.0	0.5	13028	15207	18035	453	418	-20
Lunar Touchdown	15074	212.7	2.2	0.6	11811	12805	15221	452	402	-77
Lunar Launch (lift-off)	10124	242.9	0.4	1.4	6230	3127	5348	-1	144	76
End Insertion To Hohman -Ascent	5383	254.1	0.8	2.8	3072	2832	1874	5	109	67
Burnout (Docked)	5089	254.8	0.8	2.9	2901	2689	1578	11	106	66
Completion of Crew Transfer	4474	255.2	0.6	-2.2	2579	2382	1445	17	141	58

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
Launch	0	0	10			
Earth Parking Orbit		12		12		
Translunar Injection	3	1	2	49		
Translunar Coast- Prior to Transposition	3	6		5		
-During Transposition	3	21		15		
-Subsequent to Transposition	3	51		30		
Lunar Orbit- Insertion	64	15	60	24		
-Coast Prior to Separation	64	21		6		
-Checkout	65	47	1	26		
LEM Separation and Insertion to Descent Transfer Orbit	68	4	2	17		Active Period
Coast in Descent Transfer Orbit	68	24		20	Descent*	
Powered Descent (& Hover)	69	22		58		
Lunar Staytime	69	32		10		
Powered Ascent	104	17	34	45		
Parking Orbit Contingency ***	104	24		7	Ascent**	
Coasting Ascent Transfer	105	11		47		
Rendezvous	105	19		8		
Docking	105	34		15		
Crew Transfer	105	44		10		
Dormant LEM Time			75	47		
Active LEM Time			39	57		
Post-Separation LEM Time			(37)	(40)		
Total LEM Period			115	44		

* Descent Period - 1 Hour 28 Minutes
**Ascent Period - 1 Hour 27 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
AND DISTRIBUTION OF THE INERT WEIGHT BY PERCENTAGE

		WEIGHT			PERCENTAGE				
		ASCENT	DESCENT	TOTAL	ESTIMATE	LAYOUT	CALCULATION	ACTUAL	GFE
1.0	Structure	(1293.8)	(1434.0)	(2727.8)	41.4	18.4	39.1	1.1	--
	-Ascent	1293.8	--	1293.8	22.7	25.0	49.9	2.4	--
	-Descent	--	1434.0	1434.0	58.2	12.5	29.3	--	--
2.0	Stabilization and Control	81.7	15.4	97.1	100.0	--	--	--	--
3.0	Navigation and Guidance	291.0	37.3	328.3	32.2	--	--	--	67.8
4.0	Crew Provisions *	194.6	20.0	214.6	22.7	4.5	10.3	--	62.5
5.0	Environmental Control	(374.0)	(344.0)	(718.0)	43.3	7.0	49.7	--	--
	-Hardware	237.2	89.5	326.7	13.2	15.3	71.5	--	--
	-Expendables **	136.8	254.5	391.3	68.5	--	31.5	--	--
6.0	Landing Gear	--	519.1	519.1	7.4	17.2	75.4	--	--
7.0	Instrumentation	201.8	175.0	376.8	25.9	29.0	--	--	45.1
8.0	Electrical Power Supply	759.8	656.4	1416.2	41.8	--	57.7	.5	--
9.0	Propulsion	(697.0)	(1663.9)	(2360.9)	33.4	7.7	58.9	--	--
	-Ascent Hardware	557.6	--	557.6	21.7	2.8	75.5	--	--
	-Descent Hardware	--	1140.1	1140.1	11.6	5.6	82.8	--	--
	-Helium	13.0	50.0	63.0	100.0	--	--	--	--
	-Propellant-Trapped	126.4	473.8	600.2	78.9	17.2	3.9	--	--
10.0	Reaction Control	(546.8)	--	(546.8)	73.3	22.7	4.0	--	--
	-Hardware	303.0	--	303.0	51.9	41.0	7.1	--	--
	-Helium	2.1	--	2.1	100.0	--	--	--	--
	-Propellant-Trapped, Attitude and Contingency	241.7	--	241.7	100.0	--	--	--	--
11.0	Communications	112.6	20.7	133.3	100.0	--	--	--	--
12.0	Controls and Displays	210.6	--	210.6	91.7	--	--	--	8.3
	Inert-Sub-Total - Hardware	3889.6	3917.5	7807.1	37.0	10.7	51.5	.8	--
	- Expendables and GFE ***	874.1	968.3	1842.4	56.9	5.6	8.0	--	29.5
	Inert Totals	4763.7	4885.8	9649.5	40.8	9.8	43.2	.6	5.6
	ΔV Propellant	(5001.4)	(17139.8)	(22141.2)					
	-Main Propulsion	4703.6	17139.8	21843.4					
	-Reaction Control	297.8	--	297.8					
	Totals-Earth Launch	9765.1	22025.6	31790.7					
4.0	Crew Provisions	526.5	--	526.5					
5.0	Environmental Control	-1.0	-12.3	-13.3					
7.0	Instrumentation	80.0	--	80.0					
10.0	Reaction Control - Attitude Propellant	-4.4	--	-4.4					
		8.8	--	8.8					
	Totals - Separation	10375.0	22013.3	32388.3					

* Without crew, suits, PLSS, radiation dosimeters, etc. (587.5 pounds).
** Includes trapped, LiOH cartridges, oxygen, coolant and water.
*** Includes helium and propellant.

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 (LBS)	TOTAL WEIGHT (LBS)
EARTH LAUNCH AND TRANSLUNAR INJECTION	4763.7	5001.4	4885.8	17139.8	31790.7
Crew and Equipment	+526.5				
RCS - Checkout Propellant	-4.4				
ECS - Umbilical Hardware	-1.0				
- Oxygen - SOX			-1.5		
- Water			-10.8		
Scientific Equipment	+80.0				
Comm - TV Camera	+8.8				
SEPARATION	5373.6	5001.4	4873.5	17139.8	32388.3
Water and Oxygen			-29.7		
Descent ΔV Propellant					
- Main				-17139.8	
- RCS		-18.4			
RCS- Attitude	-126.2				
LUNAR TOUCHDOWN	5247.4	4983.0	4843.8		15074.2
Scientific Samples & Equip.			-170.0		
Jettisoned on Lurain	-102.2		-4673.8		
RCS - Checkout Propellant	-4.4				
LUNAR LIFT-OFF	5140.8	4983.0			10123.8
ECS - GOX	-.8				
- Water	-25.0				
Ascent ΔV Propellant					
- Main		-4703.6			
- RCS		-279.4			
RCS- Attitude Propellant	-26.1				
BURNOUT (DOCKING)	5088.9				5088.9

[redacted]

LEM
WEIGHT STATEMENT

CODE	ITEM	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	2825.6	1293.8		1434.0		2727.8		2727.8
2.0	Stabilization and Control	101.9	81.7		15.4		97.1		97.1
3.0	Navigation and Guidance	325.8	291.0		37.3		328.3		328.3
4.0	Crew Provisions	(736.1)	(634.1)		(107.0)		(741.1)	(-526.5)	(214.6)
	-Inert	698.1	634.1		69.0		703.1	-526.5	176.6
	-Expendables	38.0	0		38.0		38.0		38.0
5.0	Environmental Control	(717.2)	(334.6)	(25.8)	(314.6)	(29.7)	(704.7)	(13.3)	(718.0)
	-Inert	384.3	280.8	0	91.0	0	371.8		371.8
	-Expendables	332.9	53.8	25.8	223.6	29.7	332.9	13.3	346.2
6.0	Landing Gear	531.1			519.1		519.1		519.1
7.0	Instrumentation	456.8	281.8		175.0		456.8	-80.0	376.8
8.0	Electrical Power	1423.5	759.8		656.4		1416.2		1416.2
9.0	Propulsion	(24355.8)	(697.0)	(4703.6)	(1663.9)	(17139.8)	(24304.3)		(24204.3)
	-Inert	2335.5	697.0	0	1663.9	0	2360.9		2360.9
	-Expendables - Δ V Propellant	22020.3	0	4703.6	0	17139.8	21843.4		21843.4
10.0	Reaction Control	(840.1)	(385.7)	(305.5)	(4.4)	(144.6)	(840.2)	(4.4)	(844.6)
	-Inert	343.9	343.9	0		0	343.9		343.9
	-Expendables - Att. Prop.	198.5	41.8	26.1	4.4	126.2	198.5	4.4	202.9
	- Δ V Propellant	297.7		279.4		18.4	297.8		297.8

[redacted]

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LEM
WEIGHT STATEMENT

CODE	ITEM	WEIGHT AT SEPARATION	BURN OUT	CONS'D ON ASCENT	JET. ON LURAIN	CONS'D ON DESCENT	TOTAL SEPARATION	X-LUNAR EXPEND-ABLES	EARTH LAUNCH TOTAL
			CURRENT WEIGHT STATUS						
11.0	Communications	127.9	118.8		23.3		142.1	-8.8	133.3
12.0	Controls and Displays Total	213.1	210.6				210.6		210.6
	-Inert	9767.5	4993.3	0	4684.4	0	9677.7	-615.3	9062.4
	-Expend. - W/O ΔV Prop.	569.4	95.6	51.9	266.0	155.9	569.4	17.7	587.1
		32654.9	5088.9	5034.9	4950.4	17314.1	32388.3	-597.6	31790.7
	Burnout Weight	5128.5	5088.9 lbs.						
	Lift-off Weight	10201.8		10123.8 lbs.					
	Touchdown Weight	15202.4			15074.2 lbs.				
	Separation Weight	32654.9					32388.3 lbs.		
	Earth Launch Weight	32057.3							31790.7 lbs.

[redacted]

Table 5

LEM WEIGHT COMPARISON
AT SEPARATION BY STAGES

Subsystem	Item	8/1/65 Weight	Current Weight	Weight
A.	Ascent Stage Weight at Separation	10452.6	10375.0	-77.6
1.0	Structure	1326.4	1293.8	-32.6
2.0	Stabilization and Control	86.5	81.7	-4.8
3.0	Navigation and Guidance	288.5	291.0	+2.5
4.0	Crew Provisions	716.1	721.1	+5.0
5.0	Environmental Control	385.5	373.0	-12.5
6.0	Landing Gear	--	--	--
7.0	Instrumentation - Operational	201.8	201.8	0
	- Scientific	80.0	80.0	0
8.0	Electrical Power Supply	767.1	759.8	-7.3
9.0	Propulsion System	(5435.2)	(5400.6)	(-34.6)
	Propulsion Inert	569.0	570.6	+1.6
	Propellant (Includes 126.4# trapped)	4866.2	4830.0	-36.2
10.0	Reaction Control	(840.1)	(840.2)	(+.1)
	Propulsion Inert	305.1	305.1	0
	Propellant (Includes 38.8# trapped)	535.0	535.1	+.1
11.0	Communications	112.3	121.4	+9.1
12.0	Controls and Displays	213.1	210.6	-2.5
B.	Descent Stage Weight at Separation	22202.3	22013.3	-189.0
1.0	Structure	1499.2	1434.0	-65.2
2.0	Stabilization and Control	15.4	15.4	0
3.0	Navigation and Guidance	37.3	37.3	0
4.0	Crew Provisions	20.0	20.0	0
5.0	Environmental Control	331.7	331.7	0
6.0	Landing Gear	531.1	519.1	-12.0
7.0	Instrumentation - Operational	5.0	5.0	0
	- Scientific	170.0	170.0	0
8.0	Electrical Power Supply	656.4	656.4	0
9.0	Propulsion System	(18920.6)	(18803.7)	(-116.9)
	Propulsion Inert	1185.0	1190.1	+5.1
	Propellant (Includes 473.8# trapped)	17735.6	17613.6	-122.0
11.0	Communications (Portable)	15.6	20.7	+5.1
	Total Separation Weight (A & B)	32654.9	32388.3	-266.6

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

	Inert * Wt. Chgs. By Stage		Effective Wt. By Responsibility	
	Ascent	Descent	GAEC	NASA
Review of Thermal/Meteoroid Shields	(-65.6)	(-40.0)	(-357.0)	
A review of thermal/meteoroid shielding requirements and configuration has resulted in a revised estimate for the LEM shielding. Review of thermal coating requirements has indicated that an anodize type finish, in lieu of paint, will be adequate. In addition, the aluminum skins were reduced from a nominal of .010 to .008 inches. Further reductions should result when the thermal meteoroid configuration is reviewed by the SWIP activity.				
1.0 Structure - skins	-41.6	-16.0	-207.0	
- paint	-24.0	-24.0	-150.0	
Miscellaneous Structure Changes	(+33.0)	(-25.2)	(+86.6)	
Current calculations of layouts and drawings indicate 20.5 pound increase in stiffener weight for the forward and aft bulkheads and the lower deck of the Ascent Stage. Since the joints, splices and fasteners weight allowance has been distributed. An estimated weight of 5 pounds has been added to structure for sealant.				
The entry of drawing weights in lieu of layout weights indicate a -6.4# calculation discrepancy per landing gear truss support installation. Another +6.3# calculation error occurred after the upper docking layout weight was previously replaced by only one drawing instead of the two it represented. Other miscellaneous structure changes increase the ascent stage weight 1.2 pounds and the descent stage .4 pounds.				
1.0 Structure				
-Stiffeners	+20.5		+87.0	
-Sealant	+5.0		+21.0	

* Inert weight excludes Δ V propellant.

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

	Inert * Wt. Chgs. By Stage		Effective Wt. By Responsibility	
	Ascent	Descent	GAEC	NASA
Miscellaneous Structure Changes - Cont.				
1.0 Structure				
-Landing Gear Truss		-25.6	-54.3	
-Upper Docking	+6.3		+27.0	
-Miscellaneous	+1.2	+ .4	+ 5.9	
Miscellaneous Environmental Control Changes	(-12.5)		(-45.0)	(-6.7)
The current review of the Atmosphere Revitalization Section indicated that the weight for the suit control valves (3.0 pounds) had been doubled and the oxygen control module (9.1 pounds) inserted erroneously. The components for the oxygen control module are carried under the Oxygen Supply and Cabin Pressure Section except the oxygen control module housing (1.8 pounds), which is added at this time.				
The review of cold plates indicates a .6 pound reduction in the cold plating for contractor furnished equipment and based on ref. (17) a 1.6 pound reduction in the cold plating of GFE (MIT) items.				
5.0 Environmental Control				
-Suit Control Valves	-3.0		-12.5	
-Oxygen Control Module (Minus housing)	-7.3		-30.0	
-CFE Cold plating	- .6		- 2.5	
-GFE Cold plating	-1.6			-6.7

*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
Descent Trapped Propellant Increase		(+18.7)	(+39.8)	
The quantity of trapped propellant in the descent stage has increased in the area of the engine, heat exchanger and propellant plumbing. Based on a vendor actual capacity check, the engine trapped propellant has increased +3.9 pounds. Increased propellant volume in the heat exchanger, for improved heat transfer between the propellant and helium, results in +.7 pound increase. Previously added drain lines and revised plumbing, in the engine compartment due to interference with the gimbal actuators and engine supports, reflects a +14.1 pound trapped propellant increase in the propellant line runs.				
9.0 Propulsion		+18.7	+39.8	
Miscellaneous Propulsion Changes	(+ 1.6)	(+ 5.1)	(+17.6)	
The vendors currently report a 1.5 pound increase in the supercritical helium heat exchanger and 1.6 pound and 3.6 pound increases in flexible hoses (ascent and descent respectively). These increase are the results of manufacturing problems including length increases.				
9.0 Propulsion				
-Supercritical Helium Heat Exchanger		+ 1.5	+3.2	
-Flexible Hoses	+ 1.6	+ 3.6	+14.4	

*Inert weight excludes Δ V 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
Light Control Weight Reduction	(-7.3)		(-30.5)	
The Lighting Control Assembly is reduced from 15.1 pounds to 7.8 pounds in accordance with ref. (18), through the use of non-dimmable dome and flood lights, the use of circuit breakers as on-off switches, etc..				
8.0 Electrical Power Supply	-7.3		-30.5	
Miscellaneous Landing Gear Changes		(-12.0)	(-25.4)	
Review of the Landing Gear indicate a weight decrease of 12 pounds. Reasons for this decrease include use of calculated weights over estimate or layout (-5.2 pounds), further machining of the (8) down lock latch fittings (-1.6 pounds) use of aluminum bearings in lieu of steel for the (24) spherical bearing assemblies (-1.6 pounds), and accounting changes (-3.6).				
6.0 Landing Gear	-12.0		-25.4	
Miscellaneous Government Furnished Equipment Change	(0)			(0)
The total weight allotted for the MIT equipment remains unchanged, however that portion of the weight not distributed to any particular part was transferred from Controls and Display to Navigation and Guidance. Then most of the undistributed weight was assigned to Government Furnished harnesses used between the MIT equipment.				
3.0 Navigation and Guidance	+ 2.5			+10.5
12.0 Controls and Displays	- 2.5			-10.5

*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
Interior Finish Allowance	(+ 5.0)		(+21.0)	
Portions of the cabin interior may require paint rather then anodizing. For this reason an allowance of 5 pounds is established for the interior finish.				
4.0 Crew Provisions	+ 5.0		+21.0	
Miscellaneous Changes	(+ 4.3)	(+ 5.1)	(+33.0)	
A new specification weight of 32.5 pounds was negotiated with the vendor on the Abort Electronic Assembly.				
2.0 Stabilization and Control	- 4.8		-20.1	
11.0 Communications (-1.9# Staged Items)				
Incorporation of Vendor reported weight changes since August 1, 1965	+ 6.3	+ 1.7	+30.1	
Review of r-f cabling, including routing and number of cables	+ 2.3	+ 2.4	+18.8	
Addition of GFE TV cables	+ .5	+ 1.0	+4.2	
Total Inert Weight Changes	-41.5	- 48.3		
Total Effective Weight Changes By Responsibility			-259.9	- 6.7

Total Reported Weight Changes = -266.6

* Inert weight excludes ΔV propellant.

Pending Changes

	Estimated Weight Increment		
	Ascent (Inert*)	Descent (Inert*)	Separation (Effective)
1. Delete the Redundant Pressurization Feed System from the Reaction Control Subsystem - Proposed Weight Reduction.	-11.1		-46.6
2. Reduce the LEM hover time by one minute- Proposed Weight Reduction is in terms of equivalent inert weight at Touchdown.		-530.0	-1130.3
3. Incorporate the Government Furnished Equipment required for extra vehicular transfer and the stowage provisions for the equipment.	-	-	
4. Incorporate the Government Furnished Tools required for intravehicular and extravehicular transfer to the CM and the stowage provisions for the tools.	-	-	
5. Provide a heated enclosure for the pyrotechnic batteries.	-	-	
7. Provisions in descent propellants tanks for installing propellant gaging probes.		+7.0	+14.0
8. Elimination of cabin Dome light	-	-	
9. Revision of Ascent Propellant tank support cones.	- 4.0		-16.8

* Inert weight excludes ΔV propellant.

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

3. MSC letter PL2-12-77/13-64-704, dated 14 December 1964, "Contract NAS 9-1100, Resolution of M-5 Mockup Review Chits 1-16- and 1-20."

4. MSC letter BG54 64-406, dated 16 December 1964, "Contract Change Authorization No. 98 Addition of LEM Design Weights to Exhibit A."

5. MSC letter PS5/L630-13-65-178, dated 9 March 1965, "Contract NAS 9-1100, Design Reference Weights for LEM GFE."

6. MSC letter PS5/L204-13-65-460, dated 4 June 1965, "Contract NAS 9-1100, Revised Δ V Budget and LEM Control Weight."

7. MSC letter BG54 65-174, dated 7 May 1965 "Cancellation or request #8 for a PCCP, LEM meteoroid protection."

8. LED-490-23, dated 1 August 1965, "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-310-58, dated 14 September 1963, "Criteria Used for RCS Tank Resizing."

12. LMO-490-105, Revision A, 29 July 1964, "Preliminary LEM Mass Property History for Control Weight and Current Status."

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

14. LMU-340-50025, dated 25 September 1964, Inboard Profile.

15. LDW-280-10050, Revision E, dated 26 May 1965, "Geometry Ascent stage -2 Tank" Drawing.

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

17. MSC letter PS5/L 618-5-65-97, dated 5 February 1965, "Incorporation of changes to LEM-ECS Cold Plate Assemblies Specification LSP-330-3."

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18. LMO-490-240, dated 22 July 1965, "LEM Lighting Control Assembly Weight."

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