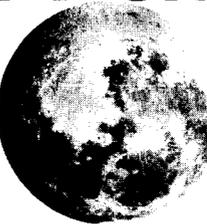


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APOLLO



GUIDANCE AND NAVIGATION

Approved: Milton B. Trageser Date: 12/17/61
MILTON B. TRAGESER, DIRECTOR
APOLLO GUIDANCE AND NAVIGATION PROGRAM

Approved: Roger B. Woodbury Date: 10/19/64
ROGER B. WOODBURY, DEPUTY DIRECTOR
INSTRUMENTATION LABORATORY

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E-1142 (Rev. 25)
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SYSTEM STATUS REPORT

October 15, 1964



INSTRUMENTATION LABORATORY

CAMBRIDGE 39, MASSACHUSETTS

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ACKNOWLEDGMENT

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ABSTRACT

The System Status Report is distributed monthly on the 15th. This month's revision of E-1142 (Rev. 25) contains, in general, the following information for the Block I (100 series) and Block II Command Module and LEM equipment configurations: weights, centers of gravity, moments of inertia, power requirements, status of computer programs, and reliability figures.

Section 1

INTRODUCTION

1-1 INTRODUCTION

The definition of what constitutes Block I, Block II, and LEM hardware is contained in the Glossary, section 5 of this report. In Block II the electronic assemblies and components are now to be hermetically sealed; the Glossary does not reflect this change in scope but will be updated by the next issue.

The following information is included in this month's report:

- (1) Command Module, Block I
100 Series: Weights and power requirements
Zero Series: Total weight, center of gravity
and moments of inertia.
- (2) Command Module, Block II
Post-June 1964 configuration: Reliability values and
"hermetically sealed" weights.
Pre-June 1964 configuration: Status of computer programs.
- (3) Lunar Excursion Module.
Pre-September 1964 configuration: Weights and reliability
values.

The significance of hermetically sealed weights mentioned above is explained in section 3 of this report.

1-2 ACCURACY

The accuracy of numerical values reported in this revision should not be considered to within the tolerances implied by the significant figures quoted. The reported values, although based upon the most current information, are subject to normal changes as design and development phases approach completion.

BLOCK I
COMMAND MODULE

Section 2

BLOCK I COMMAND MODULE DATA

2-1 WEIGHTS

Table 2-I presents the weights of all Block I flight systems (100 series systems) equipment, grouped according to specific location within the Command Module. Weights are reported to the component level and to the nearest tenth of a pound.

Given component weights are identified as estimated, calculated, and measured in the order of increasing accuracy. These terms are defined by North American Aviation as follows.

Estimated weights (E) are based on rough calculations. Calculated weights (C) are based on detailed calculations made from final production drawings that will be used to build flyable equipment. Measured weights (M) are the actual weights of equipment built to the production drawings.

North American Aviation will provide and be responsible for cold plate weights that are not integral with guidance and control equipment.

2-1.1 WEIGHTS STATUS REPORTING. Table 2-I also offers a comparison of present 100 series component weight values with those listed in System Status Report, E-1142 (Rev. 24), September 15, 1964. All weight changes are explained in paragraph 2-2.

2-1.2 CONTROL WEIGHT (ZERO SERIES). Column (a) in Table 2-I contains the February 15, 1964 weight status of Apollo G&N zero series equipment. Column (a) adds up to approximately the total control weight specified in letter PG-64-113 (March 6, 1964) from Mr. D. Gilbert, ASPO, to Mr. M. Trageser, MIT/IL.

2-1.3 DESIGN LOAD WEIGHT (ZERO SERIES). At NASA Coordination Meeting No. 15A, MIT agreed to assign "not to exceed" design load weights for individual Block I G&N zero series subsystems. These weights were assigned by MIT in MIT letter AG 594-64, May 18, 1964, and are shown in column (d) of Table 2-I. The total design load weight represents a secure maximum, since it is unlikely that the largest increases in each subsystem will occur simultaneously. The design loads listed recognize possible individual increases to account for changes accepted by NASA for the 100 series systems.

COMMAND MODULE

Table 2-1. Current Weight Status of Block I (100 Series) Command Module (lbs at 1 g)

Item	0 Series Status 2/64 (a)	(b-a)	100 Series Status 9/64 (b)	(c-b)	100 Series Status 10/64 (c)	Design Load Wt. 5/64 (d)**
<u>G&N SYSTEMS</u>						
CDU Assy	14.5 (M)	-0.9	13.6 (C)	0.0	13.6 (C)	18.0
Optical Subsystem						
SXT	18.2 (C)	+0.5	18.7 (E)	0.0	18.7 (E)	100.0
SCT	13.8 (C)	+0.5	14.3 (E)	0.0	14.3 (E)	
Optical Base & Gearing	16.7 (E)	+0.3	17.0 (E)	0.0	17.0 (E)	
Optical Eyepieces						
SXT	1.3 (E)	+0.3	1.6 (C)	0.0	1.6 (C)	65.0
SCT	2.3 (E)	+0.3	2.6 (C)	0.0	2.6 (C)	
NVB & Resilient Mounts	25.0 (E)	+0.7	25.7 (C)	0.0	25.7 (C)	
Bellows Assy	13.5 (M)	-0.8	12.7 (C)	0.0	12.7 (C)	
IMU	60.2 (M)	+0.3	60.5 (C)	0.0	60.5 (C)	
Coolant Hoses (two)	1.0 (E)	-0.2	0.8 (E)	0.0	0.8 (E)	
Power Servo Assy	59.4 (C)	-0.5	58.9 (C)	0.0	58.9 (C)	75.0
G&N Interconnection Assy	35.2 (E)	-5.2	30.0 (C)	0.0	30.0 (C)	45.0
G&N to S/C Interface Assy	8.0 (E)	+5.0	83.0 (E)	0.0	83.0 (E)	100.0
AGC (no spares)	70.0 (E)					
Optical Shroud	3.5 (M)	-0.4	3.1 (C)	0.0	3.1 (C)	4.5
<u>LOWER EQUIPMENT BAY</u>						
<u>D&C</u>						
D&C Electronics	2.9 (M)	0.0	2.9 (C)	0.0	2.9 (C)	70.0
Control Electronics	2.9 (E)	-0.9	2.0 (C)	0.0	2.0 (C)	
G&N Ind Cont Panel	9.5 (M)	+0.4	9.9 (C)	0.0	9.9 (C)	
IMU Control Panel	2.4 (M)	+0.2	2.6 (C)	0.0	2.6 (C)	
MDV (includes 1 film)	7.7 (C)	+1.9	9.6 (C)	0.0	9.6 (C)	
D&C/AGC	20.6 (M)	+0.8	21.4 (C)	0.0	21.4 (C)	
Horiz. Photo. Elect.	0.0	+3.3	3.3 (E)	0.0	3.3 (E)	0.0
Signal Conditioner Assy	0.0	4.6	4.6 (E)	0.0	4.6 (E)	8.0

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BLOCK I
COMMAND MODULE

Table 2-1. Current Weight Status of Block I (100 Series) Command Module (lbs at 1g) (cont)

	0 Series Status 2/64 (a)	(b-a)	100 Series Status 9/64 (b)	(c-b)	100 Series Status 10/64 (c)	Design Load Wt. 5/64 (d)**
<u>MAIN PANEL AREA</u> D&C/AGC	20.5 (M)	+ 0.9	21.4 (C)	0.0	21.4 (C)	26.0
<u>LOOSE STORED ITEMS</u>						
Eye Relief Eyepieces	1.5 (E)	0.0	1.5 (E)	0.0	1.5 (E)	3.0
Film Cartridges (4)	2.4 (E)	+ 0.1	2.5 (C)	0.0	2.5 (C)	5.0
Optics Cover	1.7 (M)	- 0.1	1.6 (C)	0.0	1.6 (C)	2.5
TOTAL	415.0*	10.8	425.8	0.0	425.8	522.0

*Total control weight specified in letter PG-64-114 (March 6, 1964) from Mr. D. Gilbert, ASPO, to Mr. M. Trageser, MIT/IL. See paragraph 2-1.2. Applies to zero series only.

**Design Load Weights are taken from MIT letter AG 594-64 (May 18, 1964). See paragraph 2-1.3. Applies to zero series only.

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BLOCK I
COMMAND MODULE

2-2 REPORTED 100 SERIES WEIGHT CHANGES

No weight changes were reported this month.

2-3 BLOCK I (ZERO SERIES) WEIGHT, CENTER OF GRAVITY, AND MOMENT OF INERTIA DATA

Block I (100 series) center of gravity and moment of inertia information is unavailable at this time.

Included for reference are the total Block I (zero series) weight, center of gravity, and moment of inertia values.

Table 2-II. Block I (Zero Series) Weight and Balance Data

Weight (lb)	Center of Gravity* (in)	Moments of Inertia* (lb-in ²)	
408.9	X 55.1	Ixx	681,030
	Y -0.3	Iyy	1,939,064
	Z 37.3	Izz	1,308,074

*Values determined with respect to the basic X, Y, Z axes of the Command Module.

2-4 COMMAND MODULE POWER REQUIREMENTS (100 SERIES)

The power requirements of the Command Module G&N 100 series equipment on the primary +28 VDC power supply are shown in figure 2-1 which presents the magnitude and location of dissipated power values on a subassembly level. This chart assumes a 12.85-day lunar mission as defined by S&ID for power profile computation (Ref: S&ID letter 64 MA 3540).

This power chart (figure 2-1) represents a total energy consumption decrease of approximately 700 watt hours over the 14-day lunar mission chart shown in last month's report.

Table 2-III shows the magnitude and location of power dissipation for the established G&N activities, each of which consists of various power levels of operation.

Table 2-IV shows the energy requirements for each G&N activity on a power level basis. The table is based upon MIT letter AG 679-6, "G&N Power Profile Status," dated August 14, 1963. The vertical column to the left indicates the various G&N activities (phases of operation) for the model 12.85-day mission submitted by S&ID in

COMMAND MODULE

S&ID letter 64 MA 3540. The column also indicates the power requirement and operating time for each specific activity. The top row indicates the power requirement and operating time for each G&N power consuming equipment. The table sums up the energy consumptions for each G&N activity and each G&N power consuming equipment.

BLOCK I COMMAND MODULE

Table 2-III. Nominal Power Dissipation (watts) vs G&N Activity for Block I (100 Series) Systems

M O D E	G&N Activity (power levels)	NBA		CDU JB	PSA		AGC	Thermal Load on S/C Coolant	D&C and S&C	Optics External	Electrical Load
		IMU	OBA		IMU	OBA					
A	Accomplish & Confirm Course Corrections Inactivity and Monitor Major Maneuver (1, 5)	74.5	0.0	22.1	228.5	0.0	120.0	445.1	10.7	0.0	455.8
B	Alignments Sextant Sightings (1, 3, 5, 7)	74.5	40.7	44.0	228.5	76.1	120.0	583.8	25.7	0.5	610.0
C	Landmark Trackings (Low-Orbit Navigation) (1, 4, 5, 7)	74.5	35.5	44.0	228.5	72.3	120.0	574.8	25.7	0.5	601.0
D	Star Occultation Sightings (1, 6)	25.5	0.0	0.0	36.2	0.0	120.0	181.7	10.0	0.0	191.7
E	Sextant Sightings Midcourse Navigation (1, 3, 6, 7)	25.5	40.7	21.9	36.2	76.1	120.0	320.4	25.0	0.5	345.9
F	Inactivity & Monitor (2, 6)	25.5	0.0	0.0	36.2	0.0	20.0	81.7	0.0	0.0	81.7
G	Inactivity & Monitor (2, 5)	74.5	0.0	22.1	228.5	0.0	20.0	345.1	0.7	0.0	345.8

- 1. AGC Operate 130.0 watts
- 2. AGC Standby 20.0 watts
- 3. Optics Operate SXT ON 125.8 watts
- 4. Optics Operate SXT OFF 116.8 watts
- 5. IMU Operate 325.8 watts
- 6. IMU Standby 61.7 watts
- 7. D&C Operate 28.4 watts

BLOCK I COMMAND MODULE

Table 2-IV. Block I (100 Series) Command Module Energy Consumption Profile for 12.85-Day Lunar Orbit Mission

M O D E	G&N Activity	Energy Consumption (kwh)							Total
		(1) AGC Operate 130.0 watts 81.15 hours	(2) AGC Standby 20.0 watts 227.13 hours	(3) Optics Sextant ON 125.8 watts 16.39 hours	(4) Optics Sextant OFF 116.8 watts 3.45 hours	(5) IMU Operate 325.8 watts 84.68 hours	(6) IMU Standby 61.7 watts 223.60 hours	(7) D&C Operate 28.4 watts 19.84 hours	
A	Accomplish & Confirm Course Corrections Inactivity and Monitor Major Maneuvers 455.8 watts 58.41 hours	7.593	—	—	—	19.030	—	—	26.623
B	Alignments Sextant Sightings 610.0 watts 13.73 hours	1.785	—	1.727	—	4.473	—	0.390	8.375
C	Landmark Trackings (Low-Orbit Navigation) 601.0 watts 3.45 hours	0.449	—	—	0.403	1.124	—	0.098	2.074
D	Star Occultation Sightings 191.7 watts 2.90 hours	0.377	—	—	—	—	0.179	—	0.556
E	Sextant Sightings (Midcourse Navigation) 345.9 watts 2.66 hours	0.346	—	0.335	—	—	0.164	0.076	0.921
F	Inactivity and Monitor 81.7 watts 218.04 hours	—	4.361	—	—	—	13.453	—	17.814
G	Inactivity and Monitor 345.8 watts 9.09 hours	—	0.182	—	—	2.962	—	—	3.144
	Total 398.30 hours	10.550	4.543	2.062	0.403	27.589	13.796	0.563	59.507

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BLOCK II
COMMAND MODULE

Section 3

BLOCK II COMMAND MODULE DATA

3-1 INTRODUCTION

As was stated in last month's report, the configuration of the Block II system is in a state of flux due to the activities of the Integrated Guidance and Control Implementation series of meetings at MSC which started on June 4, 1964, and are still continuing. Paragraph 3-2 on Reliability, paragraphs 3-3 and 3-4 on Weights, and paragraph 3-6 on Power recognize the new integrated guidance and control requirements. Computer programming planning has not progressed to the stage where a meaningful status can be reported to recognize the new added requirements. Accordingly, paragraph 3-5 is based upon the earlier pre-June 1964 system.

3-2 RELIABILITY

The reliability numbers shown in Table 3-I are the current estimates of the Block II Command Module G&N equipment. They reflect the realignment of the interface configuration which requires the G&N equipment to assume certain SCS functions, the elimination of the standby guidance computer, and the most recent estimate of electronic CDU reliability. These estimates of Command Module G&N reliability are based on the 138-hour mission defined in the Lunar Landing Mission Design Plan.

Table 3-I. Reliability (as of 10/15/64)

Subsystem	Operation Time (hrs) Full Power	Probability of Mission Success
IMU	31	0.9961
AGC	19*	0.9869
DSKY	19	0.99999
PSA	31*	0.99421
CDU (5)	31	0.9923
Optics	18	0.99804
Total G&N System		0.9679

*Certain assemblies function continuously.

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BLOCK II
COMMAND MODULE

Table 3-II. Current Weight Status of Block II Command Module (lbs at 1 g)

Item	Pre-June* Status 2/64 (a)	(b-a)	Post-June* Status 9/64 (b)	(c-b)	Post-June* Status 10/64 (c)	Design Load Wt. 5/64 (d)
<u>G&N SYSTEMS</u>						
CDU Assy	15.0 (E)	+ 7.9	22.9 (E)	+10.3	33.2 (E)	
Optical Subsystem						
SXT	18.2 (C)	+ 0.5	18.7 (E)	0.0	18.7 (E)	
SCT	13.8 (C)	+ 0.5	14.3 (E)	0.0	14.3 (E)	
Optical Base & Gearing	16.7 (E)	+ 0.3	17.0 (E)	0.0	17.0 (E)	
Optical Eyepieces						
SXT	1.3 (E)	+ 0.3	1.6 (E)	0.0	1.6 (E)	
SCT	2.3 (E)	+ 0.3	2.6 (E)	0.0	2.6 (E)	
NVB & Resilient Mounts	22.0 (E)	+ 1.0	23.0 (E)	0.0	23.0 (E)	
Bellows Assy	13.5 (C)	- 0.8	12.7 (C)	0.0	12.7 (E)	
IMU	42.0 (E)	+ 0.1	42.1 (E)	0.0	42.1 (E)	
Coolant Hoses (two)	1.0 (E)	- 0.2	0.8 (E)	0.0	0.8 (E)	
Power Servo Assy	41.6 (E)	0.0	41.6 (E)	+14.7	56.3 (E)	
G&N Interconnection Assy	35.2 (E)	- 5.2	30.0 (E)	+ 1.0	31.0 (E)	
G&N to S/C Interface Assy	8.0 (E)	0.0	8.0 (E)	+ 0.5	8.5 (E)	
AGC	92.5 (E)	-34.5	58.0 (E)	+10.3	68.3 (E)	
Optical Shroud	3.5 (C)	- 0.4	3.1 (E)	0.0	3.1 (E)	
<u>LOWER EQUIPMENT BAY</u>						
<u>D&C</u>						
D&C Electronics	1.5 (E)	0.0	1.5 (E)	0.0	1.5 (E)	
Control Electronics	2.9 (E)	- 0.9	2.0 (E)	0.0	2.0 (E)	
G&N Ind Cont Panel	11.1 (E)	0.0	11.1 (E)	+ 1.0	12.1 (E)	
MDV (includes 2 films)	8.3 (E)	+ 1.3	9.6 (E)	2.5	12.1 (E)	
D&C/AGC	20.6 (E)	- 5.6	15.0 (E)	+ 5.0	20.0 (E)	

(cont)

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BLOCK II
COMMAND MODULE

Table 3-II. Current Weight Status of Block II Command Module (lbs at 1 g) (cont)

Item	Pre-June* Status 2/64 (a)	(b-a)	Post-June* Status 9/64 (b)	(c-b)	Post-June* Status 10/64 (c-b)	Design Load Wt. 5/64 (d)
<u>MAIN PANEL AREA</u> D&C/AGC	20.5 (E)	- 5.5	15.0 (E)	+ 5.0	20.0 (E)	
<u>LOOSE STORED ITEMS</u> Eye Relief Eyepieces Film Cartridges (3) PSA Cover Optics Cover	1.5 (E) 1.8 (E) 3.5 (E) 1.7 (E)	0.0 + 0.1 0.0 - 0.1	1.5 (E) 1.9 (E) 3.5 (E) 1.6 (C)	0.0 0.0 - 3.5 0.0	1.5 (E) 1.9 (E) 0.0 1.6 (C)	
TOTAL	400.0** Control Weight	-40.9	359.1	+46.8	405.9	492.6***
<p>*See paragraph 3-1. **Control Weight specified in letter (PG-64-113, March 6, 1964) from Mr. D. Gilbert, ASPO, to Mr. M. Trageser, MIT/IL. See paragraph 2-1.2. ***Design Load Weight taken from S&ID letter 63 MA 2032, February 11, 1964. Does not include loose stored items. NOTE: The weight increase shown in column (c-b) is entirely the result of the implementation of hermetic sealing of components for moisture and contamination protection.</p>						

BLOCK II COMMAND MODULE

3-3 WEIGHTS

Table 3-II shows the weights of the Block II Command Module Integrated Guidance and Control system. All of the weight changes reported this month are a result of the requirement that all packages be hermetically sealed.

Because of earlier direction from MSC, the Block II G&N system provided for moisture protection by use of potting and gasketed connectors. By letter BG 53 dated August 21, 1964, from MSC, MIT was directed to use hermetic sealing of packages in the Command Module system as the basic approach for humidity and contaminant protection. This direction would allow conformal sealing, assuming specific MSC-ASPO concurrence were obtained, if weight cost, schedule, or performance would ~~not~~ be seriously affected by using hermetic sealing. Accordingly, at Implementation Meeting No. 7 on September 16, 1964, MIT presented the impact of changing to hermetic sealing by comparing it with existing moisture-proofing concepts. At this meeting it was concluded that MIT should continue with the simple moisture sealing until MSC had accessed the reported consequences of hermetic sealing. On September 23, 1964, MIT was directed by phone to proceed with full hermetic sealing of all packages.

3-4 REPORTED WEIGHT CHANGES

All weight changes shown in column (c-b) of Table 3-II are due to the hermetic sealing requirement alone. No changes are reported this month for any other cause.

The specific interpretation MIT used in establishing the hermetic seal designs resulting in the reported weight changes is as follows:

1. Leakage rate (same as preliminary NAA packaging specification):
 1×10^{-5} cc/sec. total leak for 1 cu. ft. of package at STP
2. Method of Test:
 - (a) Evacuate assembly via inlet tube.
 - (b) Fill to 7.5 psia with helium. Then crimp and solder (or braze) inlet tube.
 - (c) Place assembly in test chamber. Evacuate chamber and measure total helium leakage with helium mass spectrometer. (Helium is left in assembly at 7.5 psia.)

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COMMAND MODULE

3-4.1 CDU ASSEMBLY (+10.3 lbs.). The CDU is identical to the AGC in plane area and module/header construction. (The identical plane area was necessary for Command Module installation and was achieved by placing the AGC power supply in the same plane as the CDU header. The AGC power supply is sealed separately from the CDU adjacent to it because of logistics considerations.) Because of the identical size construction, the value of and reasons for the CDU weight increase are the same as those for the AGC (see paragraph 3-4.7 below).

3-4.2 OPTICS (No Change). The outside of the optics is protected against moisture condensation prior to launch by a heated cover which is removed for flight. During flight most of the optics are in space vacuum or a soft vacuum connected to space through labyrinth seals. The optical elements facing the inside of the cabin do not derive moisture-proofing benefit from hermetic sealing. One electronic module, a zeroing module, is on the cabin side and will be hermetically sealed by a special gasket with a negligible effect on weight. The electrical connectors to the harness will be sealed as reported below.

3-4.3 IMU (No Change). Because the IMU requires contained gas for heat transport between the inertial components and the case heat sink, the unit has already been hermetically sealed to prevent pressure changes from upsetting the thermal control. No change in weight results from the hermetic sealing requirement.

3-4.4 POWER SERVO ASSEMBLY (+14.7 lbs.). Since many PSA mounting screws, attached from the top of the PSA to the spacecraft cold plate, are no longer feasible (through the hermetic package), the cold plate concept must change. Two alternatives are possible: (1) the cold plate to header mounting screws must be attached from below the cold plate, either before or after S/C installation or (2) the coolant passages must be integral to the header, requiring disconnect fittings to the coolant system. The latter alternative was used for the weight estimate.

The net effect of integral cooling is a weight decrease in the PSA header because area is no longer required for cold plate attaching screws. This decrease, of 0.6 lbs, was incorporated in the estimate of total weight increment. Note that a significant reduction to the overall spacecraft weight occurs because the PSA cold plate is eliminated.

The PSA weight increase is due to: (1) a change from magnesium to aluminum alloy in the header (required to maintain flat sealing surfaces and to support a 7.5-psi pressure differential), (2) additional header area for seal plate and cover flange, (3) a structural cover to support the pressure differential, (4) an O-ring type gasket plate, and (5) cover mounting screws.

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3-4.5 G&N INTERCONNECT ASSEMBLY (+1.0 lbs.). This upper harness will grow because of the addition of sealed connectors. The connection to the PSA header can no longer be a simple pigtail but must be a glass to metal integral feedthrough or will require a set of hermetically sealed connectors.

3-4.6 G&N TO S/C INTERFACE ASSEMBLY (+0.5 lbs.). This lower harness will grow due to the addition of sealed connectors.

3-4.7 AGC (+10.3 lbs.). The header on which the modules are mounted increases 1.25 inches in width and 2.00 inches in depth. This area (and weight) increase results from: (1) the wider flange necessary for the O-ring type gasket seal and (2) the necessity for locating screws, which mount the AGC to S/C structure, outside the periphery of the cover. Because the cover must support a pressure differential of 7.5-psi, more than half of the weight increase is due to the structural cover. The addition of the seal plate and cover mounting hardware result in small weight increases. The total increment also includes an auxiliary header and sealing cover for the rope memory modules. This separate sealed container is necessary so that rope modules can be changed after AGC installation in the spacecraft.

3-4.8 G&N IND. CONT. PANEL (+2.0 lbs.). The increase is due to moisture proofing of the connectors, switches, handcontroller, and the brightness control assembly.

3-4.9 D&C ELECTRONICS AND CONTROL ELECTRONICS (No Change). The status of these two functions is undefined at this time. Therefore no change is reported pending further definition.

3-4.10 D&C/AGC/LEB (+5.0 lbs.). This Lower Equipment Bay DSKY will be hermetically sealed by encasing the unit in a box of sufficient strength to support the pressure differential.

3-4.11 D&C/AGC/MAIN PANEL (+5.0 lbs.). This unit will be identical with the other DSKY, paragraph 3-4.10.

3-4.12 PSA COVER (-3.5 lbs.). This dust cover is eliminated by the hermetically sealed structure, paragraph 3-4.4.

3-4.13 MAP & DATA VIEWER (+ 2 1/2 lbs.). The total weight increase is the result of moisture sealing of the equipment reported below.

3-4.13.1 Optics System (+2 lbs.). A welded one-piece sheet metal enclosure for the projection light system has been added. Passage of air from within to without and visa versa is permitted only by a pressure-balancing breathing valve whereby incoming

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air is dehumidified by the desiccant within the valve. The characteristics of the valve are such that the internal to external pressure differential shall never exceed 1 psi.

All the elements of the condenser system will now be contained in a one-piece sealed lens housing capable of withstanding pressure, negative or positive, of 15 psi maximum.

3-4.13.2 The Electronics Package (+3/8 lb.). The harness will increase due to the incorporation of waterproof connectors.

3-4.13.3 Lamp and Locket Unit (+1/8 lb.). Moisture proofing of the lamp socket and interface of lamp with socket will be accomplished in the following manner.

The socket shall be a one-piece drawn cup with leads potted into its base.

The interfacial moisture seal will be a specially designed rubber compression grommet sealing the flange of the lamp base with the flanged mouth of the lamp socket.

3-5 STATUS OF COMMAND MODULE AGC PROGRAMS

Table 3-III lists current Command Module memory estimates and the status of AGC programs.

A high and low word estimate is given with each program. Each status is defined as follows:

- (1) Planning stage
- (2) Programming stage
- (3) Checkout on AGC simulation
- (4) Checkout on G&N simulation
- (5) Checkout on AGC

3-6 POWER REQUIREMENTS

The power requirements of the Block II Command Module G&N equipment on the primary +28 VDC power supply are shown in figure 3-1, which presents the magnitude and location of dissipated power values on a subassembly level. This chart assumes a 12.85-day lunar orbit mission as defined by S&ID for power profile computation. (Ref: S&ID letter 64 MA 3540.)

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Table 3-III. Current Memory Estimates and the Status of Command Module AGC Programs (Pre-June 1964 configuration**)

Program	Status	Memory Estimate (words)	
		High	Low
List Processing Interpreter	(5)	1712	1712
AGC Executive	(5)	253	253
AGC Waitlister	(5)	145	145
AGC System Exerciser	(5)	500*	294*
G&N System Exerciser	(4)	650	400
Display, Keyboard, and Telemetry	(5)	2000	2000
Input/Output Control	(5)	1750*	1275*
Midcourse & Orbital Navigation	(5)	2000*	1500*
Midcourse & Orbital Guidance	(3)	500	500
Pre-Launch Platform Alignment	(5)	400*	350*
In-Flight Platform Alignment	(4)	1024	900
Re-Entry Control	(4)	1800	1200
Injection and De-Boost	(4)	1000	400
Restart	(5)	500*	200*
Aim-Point Determination & Abort	(3)	4000	2000
Totals		18234	13129

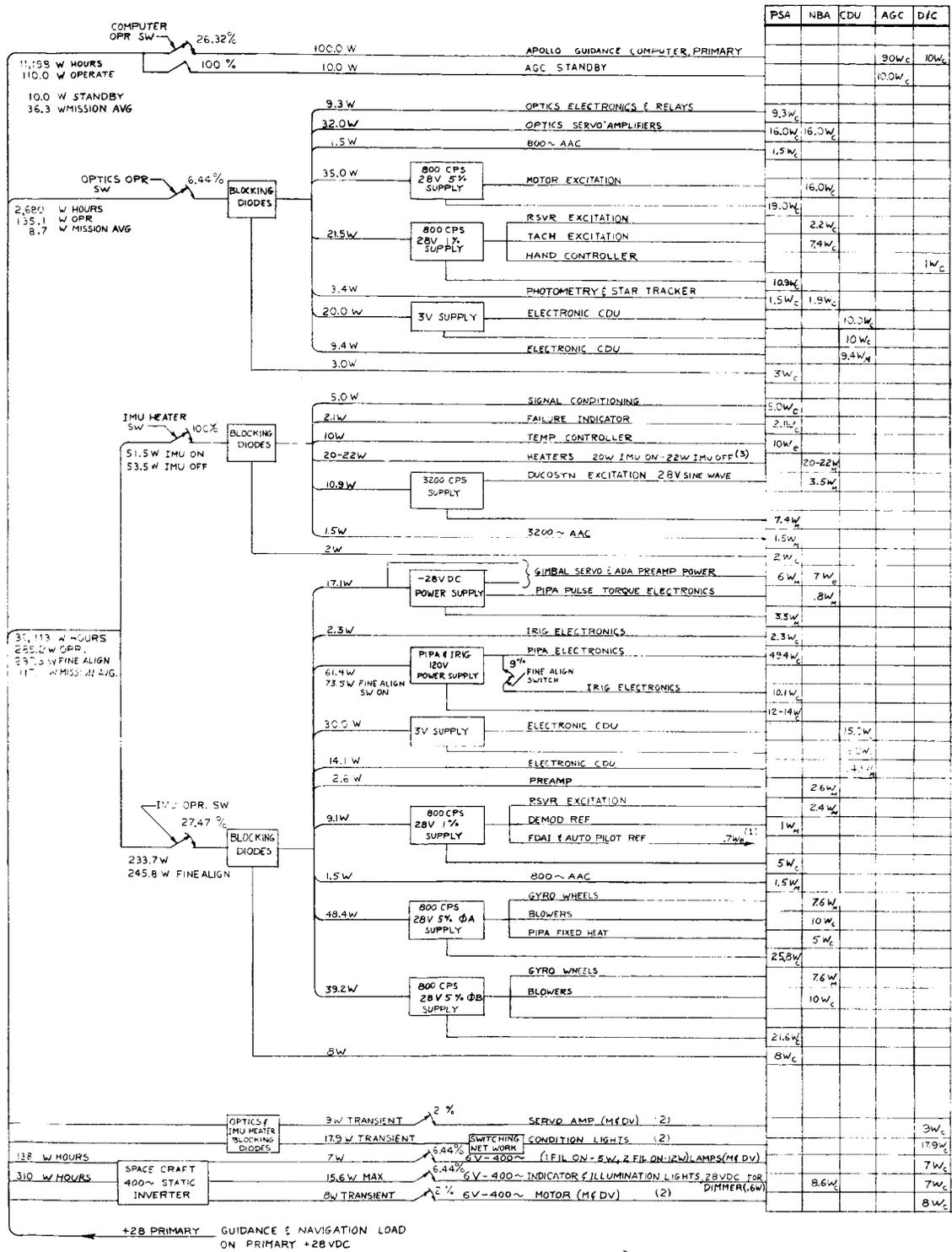
*Programs in stage (5) whose low and high estimates are not identical reflect an anticipated increase in computational facility.

**See paragraph 3-1.

Table 3-IV shows the magnitude and location dissipation for the established G&N activities, each of which consists of various power levels of operation.

Table 3-V shows the energy requirements for each G&N activity on a power level basis. The table is based upon MIT letter AG 679-6, "G&N Power Profile Status," dated August 14, 1963. The vertical column to the left indicates the various G&N activities (phases of operation) for the model 12.85-lunar day mission submitted by S&ID in S&ID letter 64 MA 3540. The column also indicates the power requirements and operating time for each specific activity. The top row indicates the power requirements and operating time of each G&N power consuming equipment. The total power energy consumptions for each G&N activity and each G&N power consuming equipment are also given.

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TOTALS: 50,439 W HOURS BASED UPON 308.3 HOURS
 163.6 W AVG. (12.85 DAY) LUNAR ORBIT MISSION
 (C) CALCULATED POWER (E) ESTIMATED POWER (M) MEASURED POWER
 (REF SEE LETTER 64 MA 3540)
 552.9 W ALL SYSTEMS OPERATING

NOTES: (1) TO SEC
 (2) INTERMITTENT OPER. (LESS THAN 1% ON TIME)
 (3) 22 W, 0 G ENVIRONMENT
 33 W, 1 G ENVIRONMENT

Figure 3-1. Electrical Load on Primary +28 VDC Power Supply

BLOCK II COMMAND MODULE

Table 3-IV. Nominal Power Dissipation (watts) vs G&N Activity for Block II Systems

M O D E	G&N Activity (power levels)	NBA		CDU	PSA		AGC	Thermal Load on S/C Coolant	D&C and S&C	Electrical Load
		IMU	OBA		IMU	OBA				
A	Accomplish & Confirm Course Corrections Major Maneuvers Inactivity & Monitor (1, 4)	76.5	0.0	44.1	163.9	0.0	100.0	384.5	10.7	395.2
B	Alignments Sextant Sightings Landmark Trackings (Low-orbit navigation) (1, 3, 4, 6)	76.5	52.1	73.5	163.9	61.2	100.0	527.2	25.7	552.9
C	Star Occultation Sightings (1, 5)	25.5	0.0	0.0	28.0	0.0	100.0	153.5	10.0	163.5
D	Sextant Sightings (Midcourse Navigation) (1, 3, 5, 6)	25.5	52.1	29.4	28.0	61.2	100.0	296.7	25.0	321.2
E	Inactivity & Monitor (2, 5)	25.5	0.0	0.0	28.0	0.0	10.0	63.5	0.0	63.5
F	Inactivity & Monitor (2, 4)	76.5	0.0	44.1	163.9	0.0	10.0	294.5	0.7	295.2

- | | |
|---|---|
| <ol style="list-style-type: none"> 1. AGC Operate 2. AGC Standby 3. Optics Operate 4. IMU Operate 5. IMU Standby 6. D&C Operate | <ol style="list-style-type: none"> 110 watts 10 watts 135.1 watts 285.2 watts 53.5 watts 22.6 watts |
|---|---|

BLOCK II COMMAND MODULE

Table 3-V. Block II Command Module Energy Consumption Profile for 12.85-Day Lunar Orbit Mission

Operating Mode	G&N Activity	Energy Consumption (kwh)						Total
		(1) AGC Operate 110.0 watts 81.15 hours	(2) AGC Standby 10.0 watts 227.13 hours	(3) Optics Operate 135.1 watts 19.84 hours	(4) IMU Operate 285.2 watts 84.68 hours	(5) IMU Standby 53.5 watts 223.60 hours	(6) D&C Operate 22.6 watts 19.84 hours	
A	Accomplish & Confirm Course Corrections Major Maneuvers Inactivity & Monitor 395.2 watts 58.41 hours	6.425	—	—	16.659	—	—	23.084
B	Alignments Sextant Sightings Landmark Trackings (Low-orbit Navigation) 552.9 watts 17.18 hours	1.890	—	2.321	4.900	—	0.388	9.499
C	Star Occultation Sightings 163.5 watts 2.90 hours	0.319	—	—	—	0.155	—	0.474
D	Sextant Sightings (Midcourse Navigation) 321.2 watts 2.66 hours	0.293	—	0.359	—	0.142	0.060	0.854
E	Inactivity & Monitor 63.5 watts 218.04 hours	—	2.180	—	—	11.665	—	13.845
F	Inactivity & Monitor 295.2 watts 9.09 hours	—	0.091	—	2.592	—	—	2.683
	Total 308.30 hours	8.927	2.271	2.680	24.151	11.962	0.448	50.439

LUNAR EXCURSION MODULE

Section 4

LUNAR EXCURSION MODULE DATA

4-1 INTRODUCTION

A series of four meetings starting September 1, 1964 have been scheduled by MSC to redefine the LEM guidance and control functions. Status reporting on the LEM hardware will be directly influenced by the activity of this new program definition phase. For this reason only best-guess estimates will be made for weight.

4-2 RELIABILITY

Expanding the LGC to enable it to handle SCS functions and an updating of the electronic CDU reliability estimate have resulted in changes in Table 4-I since the previous report. Included in Table 4-I for the first time is the DSKY reliability estimate.

Table 4-I. (Reliability as of 10/15/64)

Subsystem	Operating Time (hrs)	Probability of Mission Success
IMU	6.25	0.99914
LGC	6.25	0.9976
PSA	6.25	0.99928
CDU (5)	6.25	0.99822
OMU	0.75	0.99997
DSKY	6.25	0.9976
Total G&N System		0.9918

4-3 WEIGHTS FOR LEM

Lunar Excursion Module weights are presented in Table 4-II. In general the data conform to the information contained in paragraphs 2-1, 2-1.1, and 2-1.2.

The row labeled "Bare Guidance System" is inserted to provide for comparisons with similarly specified systems.

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LUNAR EXCURSION MODULE

Table -II. Estimated Weights of LEM G&N Components (lbs at 1 g)

Item	Status 2/64 (a)	(b-a)	Status .9/64 (b)	(c-b)	Status 10/64 (c)	Design Lead Wt. 7/64 (d)
CDU's	15.0 (E)	+ 7.9	22.9 (E)	0.0	22.9 (E)	**
Telescope and All Eyepieces	24.5 (E)	0.0	24.5 (E)	0.0	24.5 (E)	
Eye Register for Reticule	2.0 (E)	0.0	2.0 (E)	0.0	2.0 (E)	
Two-Digit Readout for Reticule	5.0 (E)	0.0	5.0 (E)	-5.0	0.0	
IMU	42.0 (E)	0.0	42.0 (E)	0.0	42.0 (E)	
LGC/PSA Interconnection Assy	10.0 (E)	0.0	10.0 (E)	0.0	10.0 (E)	
LGC Display and Controls	19.5 (E)	- 4.5	15.0 (E)	0.0	15.0 (E)	
Other Displays and Controls	15.0 (E)	0.0	15.0 (E)	-15.0	0.0	
Book of Procedures, etc.	2.0 (E)	0.0	2.0 (E)	0.0	2.0 (E)	
LGC	45.8 (E)	+16.5	58.0 (E)	0.0	58.0 (E)	
PSA	24.8 (E)	0.0	24.8 (E)	0.0	24.8 (E)	
PSA Cover	2.4 (E)	0.0	2.4 (E)	0.0	2.4 (E)	
NVB	0.0	+ 6.0	6.0 (E)	0.0	6.0 (E)	
Total	210.0*	+19.6	229.6	-20.0	209.6	
Bare Guidance System (IMU, PSA, and LGC)	108.3	0.0	124.8	0.0	124.8	
<p>*Control Weight specified in Letter PG-64-113 (March 6, 1964) from Mr. D. Gilbert, ASPO, to Mr. M. Trageser, MIT/IL. See section 2-1.2. **No design load weight has been assigned.</p>						

LUNAR EXCURSION MODULE

4-4 REPORTED WEIGHT CHANGES

Explanations for weight changes in column (c-b) of Table 4-II are given below.

4-4.1 TWO-DIGIT READOUT (-5.0 lbs). The Two-Digit Readout for Reticule has been eliminated per NASA Coordination Meeting L8A July 23, 1964 held at MSC.

4-4.2 OTHER DISPLAY AND CONTROLS (-15.0 lbs). Other Display and Controls have been eliminated per NASA Coordination Meeting L8A July 23, 1964 held at MSC.

4-5 POWER REQUIREMENTS

The estimate for LEM power and energy consumption shown in figure 4-1 is based upon Command Module G&N Block II Data and Preliminary ICD LIS-390-2, LEM Electrical Load Analysis Form.

Table 4-III shows the energy requirements for each G&N activity on a power level basis. The table is also based upon LEM ICD LIS-390-2. The vertical column on the left indicates the various G&N activities (phases of operation). This column also indicates the power requirements and operating time for each activity. The top row indicates the power requirements and operating time of each G&N power consuming equipment. The table sums up the energy consumption for power consuming equipment.

LUNAR EXCURSION MODULE

Table 4-III. Lunar Excursion Module Power Profile Based on LEM ICD LIS-390-2

M O D E	LEM G&N Activity	Energy Consumption (kwh)							Total
		(1) LGC Off 0.0 watts 87.40 hours	(2) LGC. Operate 105.0 watts 11.92 hours	(3) LGC Standby 10.0 watts 35.75 hours	(4) IMU Operate 297.3 watts 11.92 hours	(5) IMU Standby 53.5 watts 123.15 hours	(6) Two Radar CDU Operate 29.4 watts 11.92 hours	(7) OMU (AOT) Operate Negligible watts 27.42 hours	
I	Inactivity 53.5 watts 87.40 hours	0.000	—	—	—	4.676	—	—	4.676
II	Inactivity Alignment Midcourse Measurements 431.7 watts 11.72 hours	—	1.231	—	3.484	—	0.345	negligible	5.060
III	Guidance During Major Event 431.7 watts 0.20 hours	—	0.021	—	0.059	—	0.006	—	0.086
IV	Inactivity 63.5 watts 20.05 hours	—	—	0.200	—	1.073	—	—	1.273
V	Inactivity 63.5 watts 15.70 hours	—	—	0.157	—	0.840	—	negligible	0.997
	Total 135.07 hours	0.000	1.252	0.357	3.543	6.589	0.351	negligible	12.092

Section 5

GLOSSARY AND SYSTEM DEFINITION

The following definitions apply to: Block I, 100 series; Block II, configuration after June 1964; LEM, configuration prior to September 1964.

Apollo Guidance Computer (AGC)

CM BLOCK I A single complete flight computer containing all logic, memory, associated power supplies, and all interface circuits except those identified with the CDU's. Does not contain the associated displays and controls.

Consists of one case containing factory replaceable electronic modules. Includes cover for moisture-proofing, but does not include the necessary cold plate or the G&N to S/C Interface Assembly which is located in the adjacent area.

CM BLOCK II AND LEM Same as Block I except that associated power supplies are in a separate case and the CDU's are either adjacent to or on the opposite side of the same cold plate as the AGC. Memory capacity is increased over Block I.

Alignment Optical Telescope (AOT)

CM BLOCK I AND BLOCK II Not in CM; see Optical Subsystem

LEM A 3-position periscope with single-degree-of-freedom manually read reticule for alignment of the IMU. Includes the weight of the bellows assembly, a long-eye-relief eyepiece, and regular eyepiece.

Bellows Assembly

CM BLOCK I AND CM BLOCK II Two flexible pressure seals between CM structure and optical subsystem for penetration of pressure hull with optics.

LEM One bellows with a double convoluted wall and two seals providing a flexible seal for pressure penetration of the AOT in the spacecraft. This weight is included in the AOT value.

Book of Procedures

CM Not in CM; see MDV.

LEM Book or other form of maps, charts, procedures, instructions, and the like, needed for lunar operations.

Coupling Data Unit (CDU) Assembly

The CDU provides the necessary signal interfaces among the IMU gimbal angles, optics gimbal angles, radar gimbal angles, angle registers in the AGC, the spacecraft autopilot attitude error signals, and the tracking radar command error signals.

CM BLOCK I Five interchangeable gear boxes each with necessary motor tachometer, resolver synchros, and encoder with mounting frame work. Does not include associated electronics which are located in the PSA.

CM BLOCK II Functionally identical to Block I except the instrumentation is all electronic. Includes all support electronics (including special power supply) and header. Changes in resolver synchro characteristics and mode controls make Block I and II CDU's noninterchangeable.

LEM Interchangeable with CM Block II CDU's except for the headers.

Cold Plates

CM BLOCK I, BLOCK II, AND LEM Cold plates for the IMU are built into the IMU. Necessary cold plates for electronics are part of the equipment supplied by the spacecraft manufacturer. All surfaces over glycol coolant passages and open to the cabin environment will be insulated to prevent moisture condensation.

Control Electronics Assembly

CM BLOCK I Consists of one power transformer, one relay and diode module, and a bracket end connector. Used to support display and control functions. Includes moisture-proofing.

CM BLOCK II May be relocated with other similar functions.

LEM Not defined in LEM.

Coolant Hoses

CM BLOCK I AND CM BLOCK II Consists of (1) two steel flex coolant hoses, one between IMU and spacecraft and one between optics and spacecraft, (2) bracket assembly screws and clamp, and (3) entrapped coolant. A third steel flex coolant hose between the optics and the IMU is considered as part of the weight of the optics base.

LEM Not identified as part of LEM.

Display and Control/Apollo Guidance Computer (D&C/AGC)

CM BLOCK I Number displays and keyboard control associated with the operation of the AGC. Two functionally identical and parallel operation units: one in lower equipment bay and one on main panel between left and center couches.

CM BLOCK II Functionally identical to Block I but smaller configuration because of smaller relays.

LEM Identical to Block II except only a single unit is required.

D&C Electronics Assembly

CM BLOCK I Consists of a chassis, a relay and diode module, a demod. elect. module, a saturable reactor, a time delay module, a connector, and wiring. Used to support display and control functions. Connectors will be moisture-proofed.

CM BLOCK II Not defined at this time.

LEM Not defined in LEM at this time.

Eye Register for Reticule

CM Not in CM.

LEM Device or equipment not yet defined in detail, to position the pilot's eye to use the window marking reticule pattern for landing point observation and selection during the constant flight path phase of landing.

Film Cartridges

CM BLOCK I AND BLOCK II Consists of film cartridges and film for map and data viewer.

LEM Does not exist in LEM.

G&N Indicator Control Panel

CM BLOCK I AND BLOCK II Consists primarily of controls and displays for the operation of the optics, MDV, IMU temperature control, panel brightness control, and attitude impulse control. It includes display and control elements, panel, panel wiring, supporting hardware, and moisture-proofing.

LEM Does not exist in LEM.

G&N Interconnection Assembly

CM BLOCK I Consists of PSA End Connector Assembly and interconnect wiring harness, which electrically ties together the assemblies that constitute a completely integrated system. This term does not include weights of harness support brackets, which are an NAA responsibility, or the G&N to S/C Interface Assembly weight.

CM BLOCK II Similar to Block I but not interchangeable with Block I.

LEM Not clearly defined but at present is called the AGC/PSA Interconnection Assy. Because of the wide separation of G&N components, most interconnection will be accomplished as part of spacecraft wiring.

G&N to S/C Interface Assembly

CM BLOCK I Cable interconnections between the spacecraft wiring channel, the computer connector, and the PSA end connector. Contains no active electronics.

CM BLOCK II Similar in function to Block I except the configuration is much different and not interchangeable with Block I.

LEM Not identified yet as a separate item in LEM.

Horizon Photometer

CM BLOCK I AND BLOCK II An earth horizon brightness photometer and automatic star tracker used for navigation measurements against the earth's illuminated limb. The sensors are incorporated into the head of the SXT the weight of which includes this function. The PSA includes all support electronics for Block II and some of the support electronics for Block I.

LEM Not a part of LEM.

Horizon Photometer Electronics

CM BLOCK I Additional horizon photometer and star tracker electronics mounted on an auxiliary header and attached to the right-hand wall behind the MDV.

CM BLOCK II All electronics are located in the PSA or on the sextant head.

LEM Not required.

Inertial Measurement Unit (IMU)

CM BLOCK I Size 14 IMU (14-inch case diameter) gimbal assembly including all parts inside hermetic case, entrapped coolant, and heat exchanger insulation.

CM BLOCK II AND LEM Size 12.5 IMU functionally interchangeable with Block I unit, but not physically interchangeable with Block I.

IMU Control Panel

CM BLOCK I Consists of panel, wiring, attitude error meter, CDU transfer switch, manual alignment switch, CDU mode control switches, connector, supporting hardware, and associated moisture-proofing.

CM BLOCK II Does not exist in Block II. Moding is done by AGC program and AGC push buttons.

LEM Does not exist in LEM.

Long-Eye-Relief Eyepieces

CM BLOCK I AND BLOCK II Consists of a SXT and a SCT eyepiece to provide eye relief of at least 1.6 inches for closed-visor operation. Used in place of normal eyepieces of SXT and SCT.

LEM Long-eye-relief eyepiece is included as part of the AOT.

Map and Data Viewer (MDV)

CM BLOCK I AND BLOCK II Film viewer for display of maps, charts, procedures, and the like. Weight includes one film cartridge. An MDV cover is also included for moisture-proofing.

LEM Not in LEM; see Book of Procedures.

NVB and Resilient Mounts

CM BLOCK I Rigid beryllium structure supporting the IMU and the optical subsystem with its associated hardware. The NVB is attached to the spacecraft using flexible resilient mounts to prevent spacecraft strains from distorting the NVB and the alignment between the IMU and optics. These mounts also provide shock and vibration attenuation.

CM BLOCK II Functionally similar to Block I but will be lighter and provide for mounting the size 12.5 IMU. The Block II NVB will have a transition piece as a result of the reorientation of the NVB so that the IMU axes will be parallel to the Command Module axes.

LEM A toroidal aluminum ring with: (1) four tubular aluminum posts to provide for IMU mounting, (2) four tubular aluminum posts for AOT mounting, and (3) three aluminum inserts to provide strain isolation ball mounting to the GAEC structure.

Optical Eyepieces

CM BLOCK I AND BLOCK II Removable SXT eyepiece and SCT eyepiece.

LEM Included as part of the AOT.

Optical Subsystem

CM BLOCK I AND BLOCK II Consists of SXT, SCT, Optical Base, and associated hardware defined as follows:

- SXT: Sextant. A two-line-of-sight, narrow-field, two-degree-of-freedom sextant and its attached gearing. The horizon photometer and automatic star tracker sensors are incorporated into the SXT head.
- SCT: Scanning Telescope. A single-line-of-sight, wide-field-of-view, two-degree-of-freedom articulation optical instrument and its attached gearing.
- Optical Base: Base for SXT and SCT with associated gearing and internal cooling. Includes the weight of the coolant hose between the IMU and Optical Base.

LEM Not in LEM; see AOT.

Optical Shroud & Cover Assembly

CM BLOCK I AND BLOCK II Consists of the optical shroud and protective cover.

LEM Does not exist in LEM.

Power Servo Assembly (PSA)

CM BLOCK I Includes most of the support electronics: power supplies; IMU, Optics, and CDU servos; IMU temperature control; accelerometer and gyro pulse torquing; and horizon photometer and automatic star tracker electronics. Consists of 10 trays with replaceable modules which plug into the PSA end connector assembly. Includes a beryllium front toe plate.

CM BLOCK II Similar in function to Block I except that all horizon photometer electronics are included in the Block II PSA, and the CDU servos are deleted. Consists of a single plane matrix header, mounted to a cold plate, with the modules plugging onto the top.

LEM Consists of electronics similar to those identified in the Block II PSA minus various electronics modules. Does not include optics and photometry electronics associated with the Block I and II PSA's.

PSA End Connector Assembly

CM BLOCK I Electrical interconnection between the PSA trays, the G&N Interconnection Assy, and the G&N to S/C Interface Assy. The End Connector weight is reported in the G&N Interconnection Assembly weight.

CM BLOCK II AND LEM Not identified as a separate item; will be part of the PSA matrix header.

PSA Covers

CM BLOCK I Ten plastic connector covers, gaskets, and mounting screws (one for each tray) for moisture proofing.

CM BLOCK II Cover to protect the PSA module connections from moisture during flight.

LEM Same as Block II except lighter in weight.

Signal Conditioner Assembly

CM BLOCK I AND BLOCK II AND LEM Conditions signals for telemetry.

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Feldman, J. B.	Ladd, D.	Stameris, W.
Flanders, J.	Larson, L.	Trageser, M.
Felix, S. (S&ID)	Lawrence, J. (GAEC)	Wilk, L. (2)
		Woodbury, R.

External

Delaney, Major, W. (AFSC/MIT)	(1)	Small, J. (GAEC/RASPO)	(1)
Gregorek, S. (NAA S&ID/MIT)	(1)	AC Spark Plug	(10)
Heuermann, T. (GAEC/MIT)	(1)	Kollsman	(10)
Rhine, W (NASA/RASPO/MIT)	(1)	Raytheon	(10)

NAA RASPO: National Aeronautics and Space Administration (1)
 Resident Apollo Spacecraft Project Officer
 North American Aviation, Inc.
 Space and Information Systems Division
 12214 Lakewood Boulevard
 Downey, California

HDQ: NASA Headquarters (6)
 1560 H Street
 Washington, D. C.
 Attn: Mr. G. M. Low, MD (P)

GAEC: Grumman Aircraft Engineering Corporation (1)
 Bethpage, Long Island
 New York
 Attn: Mr. A. Whitaker

NAA:

North American Aviation, Inc. (1)
Space and Information System Division
12214 Lakewood Boulevard
Downey, California
Attn: Mr. R. Berry (1)

MSC:

National Aeronautics and Space Administration (41)
Manned Spacecraft Center
Houston 1, Texas
Apollo Document Control Group (SDG) (35)
Apollo Command and Service Module (3)
Attn: Mr. F. Peters
Attn: Mr. P. Ebersole (2)

WESCO

Washington Engineering Services Co., Inc. (1)
White Flint Science Park
Kensington, Maryland
Attn: Mr. J.P. Smith

WESCO (2)
68 Rogers Street
Cambridge 39, Massachusetts
Attn: Mr. J. Levy (2)

ACSP RASPO:

National Aeronautics and Space Admin. (1)	Mr. S. Schwartz (1)
Resident Apollo Spacecraft Program Officer	Quenns Material Quality Section
Dept. 32-31	c/o Kollsman Instrument Corp.
AC Spark Plug Div. of General Motors	Building A
Milwaukee, Wisconsin	80-08 5 Ave
Attn: Mr. W. Swingle	Elmhurst, New York 11373
Mr. H. Peterson (1)	Mr. H. Anschuetz (1)
Bureau of Naval Weapons	USAF Contract Mgt. District
c/o Raytheon Company	AC Spark Plug Div. of General Motors
Foundry Avenue	Milwaukee, Wisconsin 53201
Waltham, Massachusetts	