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APOLLO

GUIDANCE AND NAVIGATION

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E-1142 (Rev. 31)

(UNCLASSIFIED TITLE)

SYSTEM STATUS REPORT

April 15, 1965

INSTRUMENTATION LABORATORY

CAMBRIDGE 39, MASSACHUSETTS

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ABSTRACT

The System Status Report is distributed monthly on the 15th. This month's revision of E-1142 (Rev. 31) contains, in general, the following information for the Block I and Block II Command Module and Lunar Excursion Module equipment: configuration weights, centers of gravity, moments of inertia, power requirements, status of computer programs, and reliability values.

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.

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

(1) Command Module, Block I
100 Series: Weights and power requirements
Zero Series: Centers of gravity and moments of inertia
Guidance and Navigation Lunar Landing Mission: Status of computer programs.

(2) Command Module, Block II
Integrated Guidance, Navigation, and Control Configuration: Weights and reliability values.

(3) Lunar Excursion Module
LEM Integrated Guidance and Control Configuration (Configuration "B." Ref: Minutes of LEM Implementation Meeting No. 4): Weights and reliability values.

1-2 ACCURACY

The accuracy of numerical values reported in this revision should not be considered to be 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.

Section 2

BLOCK I COMMAND MODULE DATA

2-1 WEIGHTS

Table 2-I presents the weights of all Block I flight (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 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 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 WEIGHT 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. 30), March 15, 1965. All weight changes are explained in paragraph 2-2.

2-1.2 CONTROL WEIGHT (100 SERIES). Column (a) in Table 2-I contains the total control weight for the Apollo G&N 100 series equipment as specified in letter EG-151-44-65-55 (February 10, 1965) from Mr. R.W. Young, ASPO, to Mr. M. Trageser, MIT/IL.

2-1.3 DESIGN LOAD WEIGHT (100 SERIES). Column (d) of Table 2-I contains the "not to exceed" design load weights for individual Block I G&N 100 series subsystems These weights were assigned per ICD MH01-01256-416, January 4, 1965.

2-2 REPORTED 100 SERIES WEIGHT CHANGES

2-2.1 CONDITION ANNUNCIATOR ASSY (+1.2 lbs). This assembly has been added to visually display G&N system malfunctions. This function was previously part of the MDV which was removed in last month's report.

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

Item	100 Series Control Weight (a)	(b-a)	100 Series Status 3/65 (b)	(c-b)	100 Series Status 4/65 (c)	100 Series ~~Design~~ Load Wt. 1/65 (d)
G&N SYSTEMS						
CDU Assy			14.1 (E)	0.0	14.1 (E)	18.0
Optical Subsystem						
SXT			18.7 (E)	0.0	18.7 (E)	
SCT			14.3 (E)	0.0	14.3 (E)	
Optical Base & Gearing			17.0 (E)	0.0	17.0 (E)	
Optical Eyepieces						100.0
SXT			1.6 (C)	0.0	1.6 (C)	
SCT			2.6 (C)	0.0	2.6 (C)	
NVB & Resilient Mounts			25.7 (M)	0.0	25.7 (M)	
Bellows Assy			12.7 (M)	0.0	12.7 (M)	
IMU			60.5 (C)	0.0	60.5 (C)	65.0
Coolant Hoses (two)			0.8 (E)	0.0	0.8 (E)	
Power Servo Assy			59.8 (C)	0.0	59.8 (C)	75.0
G&N Interconnection Assy			25.0 (E)	0.0	25.0 (E)	45.0
G&N to S/C Interface Assy			87.0 (M)	0.0	87.0 (M)	100.0
AGC (no spares)						
Optical Shroud			3.1 (E)	0.0	3.1 (E)	4.5
LOWER EQUIPMENT BAY						
D&C						
D&C Electronics			3.0 (E)	0.0	3.0 (E)	
Control Electronics			2.1 (E)	0.0	2.1 (E)	
G&N Ind Cont Panel			10.5 (E)	0.0	10.5 (E)	
IMU Control Panel			2.8 (E)	0.0	2.8 (E)	70.0
Condition Annunciator Assy			0.0	+1.2	1.2 (E)	
D&C/AGC			23.0 (M)	0.0	23.0 (M)	
Horizon Photo. Elect.			2.2 (C)	0.0	2.2 (C)	4.0
Signal Conditioner Assy			3.9 (C)	0.0	3.9 (C)	8.0

(cont)

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

Item	100 Series Control Weight (a)	(b-a)	100 Series Status 3/65 (b)	(c-b)	100 Series Status 4/65 (c)	100 Series Design Load Wt. 5/64 (d)
MAIN PANEL AREA						
D&C/AGC			23.0 (M)	2.2	25.2 (E)	26.0
LOOSE STORED ITEMS						
Eye Relief Eyepieces			1.5 (E)	0.0	1.5 (E)	3.0
Optics Cover			1.6 (C)	0.0	1.6 (C)	2.5
TOTAL	430.0*	-13.5	416.5	+3.4	419.9	522.0 ∤

*Total control weight specified in letter EG-151-44-65-55 (February 10, 1965), from Mr. R.W. Young, ASPO, to Mr. M. Trageser, MIT/IL. See paragraph 2-1.2 Applies to 100 series only.

∤Design Load Weights are taken from ICD MH01-01256 (January 4, 1965). See paragraph 2-1.3.

2-2.2 D&C/AGC MAIN PANEL (+2.2 lbs). The weight increase is due to the addition of a piece of fail-safe alarm detection equipment, termed "nightwatchman," which is added to the back of the Main Panel DSKY to meet requirements first identified in the planning for flight 202. Nightwatchman acts on all previously identified failure detections under computer program as well as indicating computer failures due to circuit non-functioning.

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, but is under preparation.

Included for reference are the total Block I (zero series) weight, center of gravity, and moment of inertia values (Table 2-II).

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

Weight (lb)	Center of Gravity (in)	Moments of Inertia* ($lb\text{-}in^2$)
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 8.25-day mission, as defined by the Apollo Mission Planning Task Force (AMPTF) for power profile computation, and is based on a 28 VDC input at the connectors. The values shown are average values. (Ref: GAEC Report No. LED-540-12, October 30, 1964.)

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 8.25-day mission submitted by the AMPTF (GAEC Report No. LED-540-12, October 30, 1964). This 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 consumption for each G&N activity and each G&N power consuming equipment.

BLOCK I

COMMAND MODULE

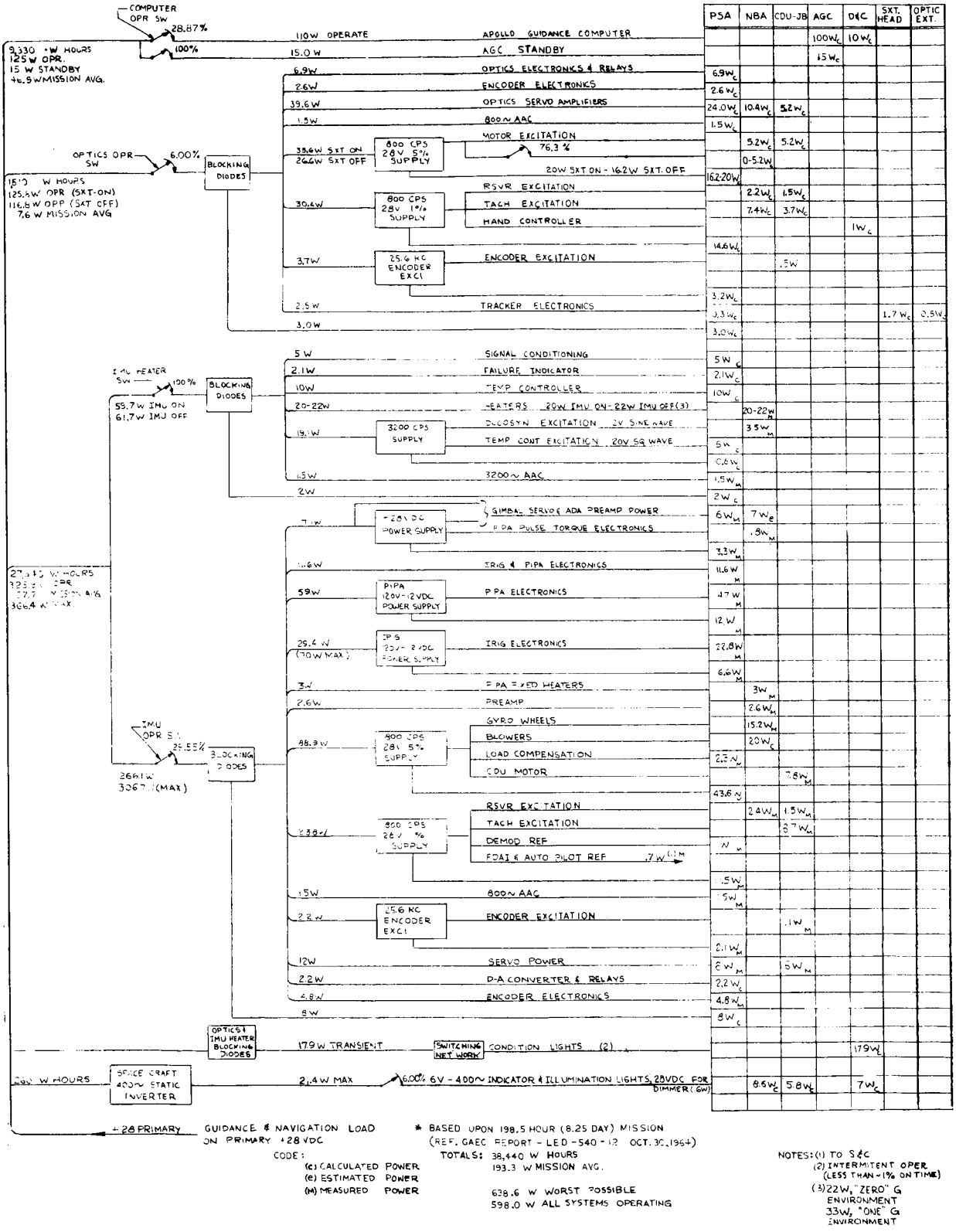

Figure 2-1. Electrical Load on Primary +28 VDC Power Supply for Block I (100 Series) Systems

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

MODE	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	D&C and OBA	IMU	D&C and OBA	IMU	OBA					
A	Accomplish & Confirm Course Corrections Inactivity & Monitor Major Maneuvers (1, 5)	74.5	0.0	22.1	0.0	228.5	0.0	115.0	440.1	10.7	0.0	450.8
B	IMU Alignments Sextant Sightings (Midcourse Navigation) (1, 3, 5, 7)	74.5	40.7	22.1	21.9	228.5	76.1	115.0	578.8	18.7	0.5	598.0
C	Landmark Trackings (Low-orbit Navigation) (1, 4, 5, 7)	74.5	35.5	22.1	21.9	228.5	72.3	115.0	569.8	18.7	0.5	589.0
D	Inactivity & Monitor (1, 6)	25.5	0.0	0.0	0.0	36.2	0.0	115.0	176.7	10.0	0.0	186.7
E	Sextant Sightings (Midcourse Navigation) (1, 3, 6, 7)	25.5	40.7	0.0	21.9	36.2	76.1	115.0	315.4	18.0	0.5	333.9
F	Inactivity & Monitor	25.5	0.0	0.0	0.0	36.2	0.0	15.0	76.7	0.0	0.0	76.7

1. AGC Operate 125.0 watts
2. AGC Standby 15.0 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 21.4 watts

Table 2-IV. Block I (100 Series) Command Module Energy Consumption Profile for 8.25-Day Lunar Orbit Mission

MODE	G&N Activity	Energy Consumption (kwh)							
		(1) AGC Operate 125.0 watts 57.38 hours	(2) AGC Standby 15.0 watts 141.31 hours	(3) Optics Sextant ON 125.8 watts 9.08 hours	(4) Optics Sextant OFF 116.8 watts 2.83 hours	(5) IMU Operate 325.8 watts 56.73 hours	(6) IMU Standby 61.7 watts 141.96 hours	(7) D&C Operate 21.4 watts 11.91 hours	Total
A	Accomplish & Confirm Course Correction Major Maneuvers Inactivity & Monitor 450.8 watts 45.12 hours	5.640	—	—	—	14.700	—	—	20.340
B	IMU Alignments Sextant Sightings (Midcourse Navigation) 598.0 watts 9.08 hours	1.135	—	1.142	—	2.958	—	0.194	5.429
C	Landmark Tracking (Low-Orbit Navigation) 589.0 watts 2.83 hours	0.354	—	—	0.330	0.922	—	0.060	1.666
D	Inactivity & Monitor 186.7 watts 0.35 hours	0.044	—	—	—	—	0.022	—	0.066
E	Sextant Sightings (Midcourse Navigation) 333.9 watts 0.30 hours	0.038	—	0.038	—	—	0.019	0.006	0.101
F	Inactivity & Monitor 76.7 watts 141.31 hours	—	2.119	—	—	—	8.719	—	10.838
	Total 198.55 hours	7.211	2.119	1.181	0.330	18.580	8.760	0.260	38.440

2-5 STATUS OF COMMAND MODULE AGC PROGRAMS

The integrated guidance and control implementation activity has defined stabilization and control functions which must be part of the Block II computer program. Since the current program estimates do not include these S&C functions, the computer program status has been moved from section 3 to section 2 where it applies to the Block I configuration used for a lunar mission but without S&C. When the computer estimates include these added functions, the AGC program status will be returned to section 3.

Table 2-V lists current Command Module memory estimates and the status of AGC programs for the lunar landing mission guidance and navigation functions.

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

Table 2-V. Current Memory Estimates and the Status of Command Module AGC Programs (4/15/65)

Item	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 computation facility.

Section 3

BLOCK II COMMAND MODULE DATA

3-1 RELIABILITY

MIT was informed on March 24, 1965, by Mr. C.W Frasier of MSC G&C that NASA is in the process of preparing specific ground rules for MIT to follow in applying the Apollo Mission Planning Task Force (AMPTF) time line to the determination of mission success probability of the G&N system. MIT has discontinued calculating reliability figures for this report until these new ground rules are received.

Table 3-I shows reliability figures based on the old 138 hour mission as defined in the Lunar Landing Mission Design Plan.

Table 3-I. Reliability (as of 1/15/65)

Subsystem	Operating 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.

3-2 WEIGHTS FOR THE BLOCK II COMMAND MODULE

Table 3-II shows the weights of the Block II Command Module Integrated Guidance and Control System.

3-3 REPORTED BLOCK II WEIGHT CHANGES

No weight changes were reported this month.

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

Item	Design Weight (a)	(b-a)	Status 3/65 (b)	(c-b)	Status 4 /65 (c)	Design Load Wt. 5/64 (d)
G&N SYSTEMS						
CDU Assy			33.0 (E)	0.0	33.0 (E)	
Optical Sybsystem						
SXT			18.7 (E)	0.0	18.7 (E)	
SCT			14.3 (E)	0.0	14.3 (E)	
Optical Base & Gearing			17.0 (E)	0.0	17.0 (E)	
Optical Eyepieces						
SXT			1.6 (E)	0.0	1.6 (E)	
SCT			2.6 (E)	0.0	2.6 (E)	
NVB & Mounts			17.0 (E)	0.0	17.0 (E)	
Bellows Assy			12.7 (E)	0.0	12.7 (E)	
IMU			42.1 (E)	0.0	42.1 (E)	
Coolant Hoses (two)			0.8 (E)	0.0	0.8 (E)	
Power Servo Assy *			41.5 (E)	0.0	41.5 (E)	
PIPA Electronics Assy			7.9 (E)	0.0	7.9 (E)	
Interconnect Harness Assy			30.0 (E)	0.0	30.0 (E)	
AGC			58.0 (E)	0.0	58.0 (E)	
Optical Shroud			3.1 (E)	0.0	3.1 (E)	
LOWER EQUIPMENT BAY						
D&C						
G&N Ind Cont Panel			12.1 (E)	0.0	12.1 (E)	
D&C/AGC			17.5 (E)	0.0	17.5 (E)	
Signal Conditioner Assy			3.9 (C)	0.0	3.9 (C)	
MAIN PANEL AREA						
D&C/AGC			17.5 (E)	0.0	17.5 (E)	

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

	Design Weight (a)	(b-a)	Status 3/65 (b)	(c-d)	Status 4/65 (c)	Design Load Wt. 5/64 (d)
LOOSE STORED ITEMS						
Eye Releif Eyepieces			1.5 (E)	0.0	1.5 (E)	
Optics Cover			1.6 (E)	0.0	1.6 (E)	
Total	400.0 ∤	-26.2	373.8	0.0	373.8	492.6 §

*Includes the weight of the PSA Cover.
∤Total Control Weight specified in letter EG-151-44-65 (February 10. 1965) from Mr. R. W. Young, ASPO, to Mr. M. Trageser, MIT/IL. See paragraph 2-1.2.
§Design Load Weight taken from S&ID letter 64 MA 2032 (February 11, 1964). It doed not include loose stored items.

3-4 BLOCK II MOMENT OF INERTIA DATA

Although the Block II G&N system is still in the developmental stage, the mass moment of inertia has been calculated for the IMU and the Nav Base Assembly. The mass moment of inertia for the Block II IMU was obtained by utilizing the Block II vibration model and the Block I stable member. The Block II Nav Base Assembly utilized for determining the moment of inertia is the environmental test model which was designed to be representative of the Block II Nav Base Assembly, unless future testing shows redesign to be necessary.

The moments of inertia of each have been calculated about their respective centers of gravity about axes which are parallel to the axes of the Command Module (Table 3-III).

Table 3-III Mass Moment of Inertia (slug-ft^2)

Assembly	Ix	Iy	Iz
IMU Assembly	0.1032	0.1289	0.1199
Nav Base Assembly	0.1662	0.1785	0.2920

3-5 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 an 8.25-day lunar orbit mission as defined by the Apollo Mission Planning Task Force (AMPTF) for power profile conputation and is based on a 28 VDC input at the connectors. These values are average values (Ref: GAEC Report LED-540-12, October 30, 1964). Since Block II PSA has been divided into two environmentally sealed assemblies each with its separate cold plate, the power profile chart has been recalculated to reflect the dispersion of dissipated power to the PSA and PIPA Electronics Assembly.

Table 3-IV 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 3-V shows the energy requirements for each G&N activity on a power level basis. The table is based on 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 8.25-day lunar mission submitted by AMPTF (GAEC Report LED-540-12, October 30, 1964). This 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 consumption for each G&N activity and each G&N power consuming equipment is also given.

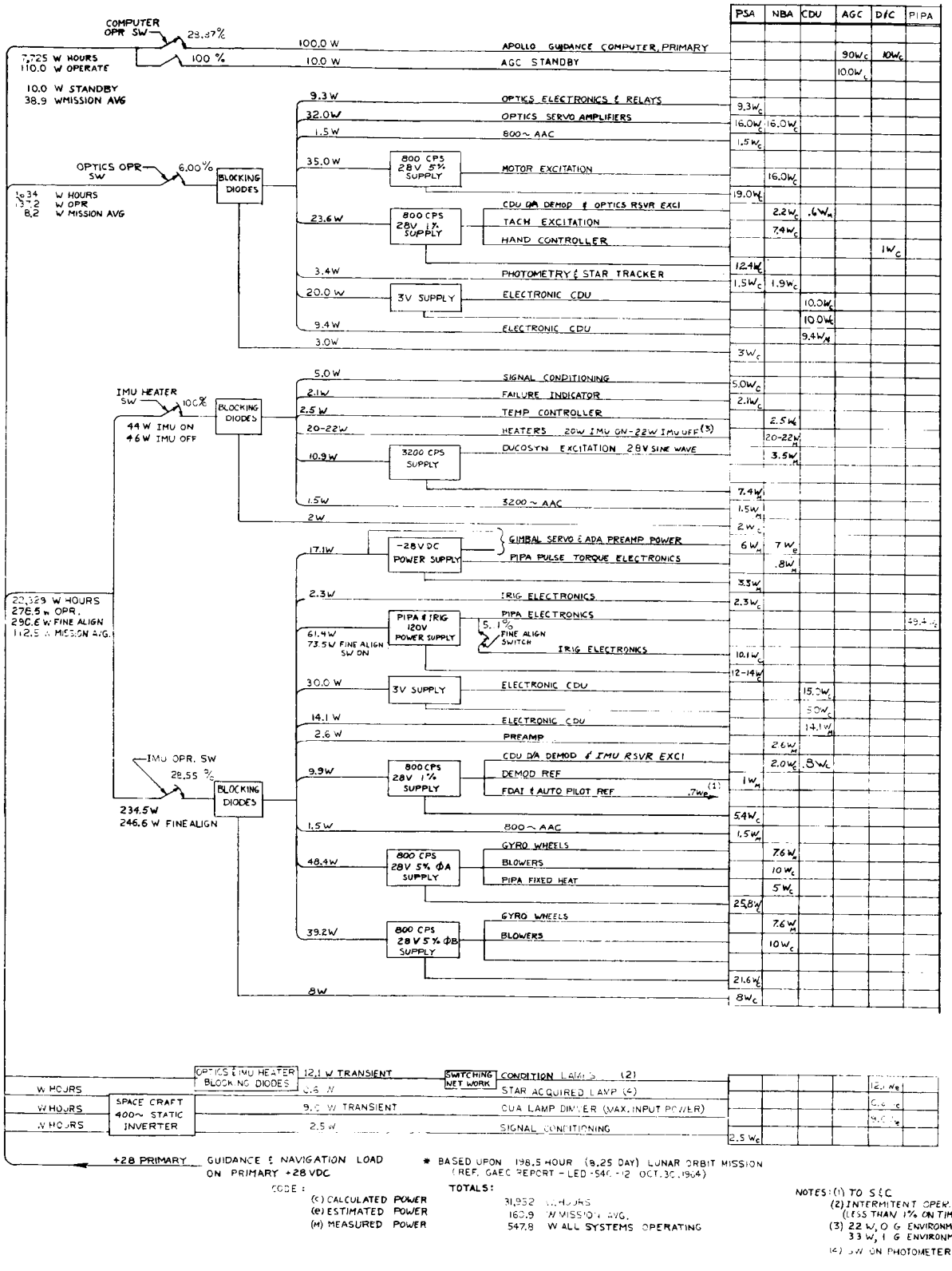

Figure 3-1. Electrical Load on Primary +28 VDC Power Supply

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

MODE	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	IMU	OBA				
A	Accomplish & Confirm Course Corrections Inactivity & Monitor Major Maneuvers (1, 4)	78.6	0.0	44.9	0.0	154.3	0.0	100.0	377.8	10.7	388.5
B	IMU Alignments Sextant Sightings (Midcourse Navigation) Landmark Tracking (Low-orbit Navigation) (1, 3, 4, 6)	78.6	43.7	44.9	30.0	154.3	62.7	100.0	514.0	33.8	547.8
C	Inactivity & Monitor (1, 5)	28.0	0.0	0.0	0.0	18.0	0.0	100.0	146.0	10.0	156.0
D	Sextant Sightings (Midcourse Navigation) (1, 3, 5, 6)	28.0	43.7	0.0	30.0	18.0	62.7	100.0	282.2	33.1	315.3
E	Inactivity & Monitor (2,5)	28.0	0.0	0.0	0.0	18.0	0.0	10.0	56.0	0.0	56.0

1. AGC Operate 110.0 watts
2. AGC Standby 10.0 watts
3. Optics Operate 137.2 watts
4. IMU Operate 278.5 watts
5. IMU Standby 46.0 watts
6. D&C Operate 22.1 watts

Table 3-V. Block II Command Module Energy Consumption Profile for 8.25-Day Lunar Orbit Mission

MODE	G&N Activity	Energy Consumption (kwh)						
		(1) AGC Operate 110.0 watts 57.38 hours	(2) AGC Standby 10.0 watts 141.31 hours	(3) Optics Operate 137.2 watts 11.91 hours	(4) IMU Operate 278.5 watts 56.73 hours	(5) IMU Standby 46.0 watts 141.96 hours	(6) D&C Operate 22.1 watts 11.91 hours	Total
A	Accomplish & Confirm Course Corrections Major Maneuvers Inactivity & Monitor 388.5 watts 45.12 hours	4.963	—	—	12.566	—	—	17.529
B	IMU Alignments Sextant Sightings (Midcourse Navigation) Landmark Trackings (Low-orbit Navigation) 547.8 watts 11.61 hours	1.277	—	1.593	3.233	—	0.257	6.360
C	Inactivity & Monitor 156.0 watts 0.35 hours	0.039	—	—	—	0.016	—	0.055
D	Sextant Sightings (Midcourse Navigation) 315.3 watts 0.30 hours	0.033	—	0.041	—	0.014	0.007	0.095
E	Inactivity & Monitor 56.0 watts 141.31 hours	—	1.413	—	—	6.500	—	7.913
	Total 198.55 hours	6.312	1.413	1.634	15.799	6.530	0.264	31.952

Section 4

LUNAR EXCURSION MODULE DATA

4-1 RELIABILITY

MIT has discontinued calculating reliability figures for this report until receipt of specific ground rules from MSC for MIT to follow in applying the AMPTF time line for determining mission success probability of the G&N system. (For further explanation see paragraph 3-1.)

Table 4-I shows reliability figures based on the old 138-hour mission as defined in the Lunar Landing Mission Design Plan.

Table 4-I. Reliability (as of 1/15/65)

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

4-2 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.

4-3 REPORTED LEM WEIGHT CHANGES

No weight changes were reported this month.

Table 4-II. Estimated Weights of LEM G&N Command Module (lbs at 1 g)

Item	Control Weight (a)	(b-a)	Status 3/65 (b)	(c-b)	Status 4/65 (c)	Design Load Wt. 7/64 (d)
CDU's			33.0 (E)	0.0	33.0 (E)	*
Telescope and All Eyepieces			25.5 (E)	0.0	25.5 (E)	
Landing Point Designator			2.0 (E)	0.0	2.0 (E)	
IMU			42.1 (E)	0.0	42.1 (E)	
LGC/PSA Interconnection Assy			10.0 (E)	0.0	10.0 (E)	
LGC Display and Controls			17.5 (E)	0.0	17.5 (E)	
Book of Procedures, etc.			2.0 (E)	0.0	2.0 (E)	
LGC			58.0 (E)	0.0	58.0 (E)	
NVB			6.0 (E)	0.0	6.0 (E)	
PSA			15.2 (E)	0.0	15.2 (E)	
Pulse Torque Assy (PTA			12.0 (E)	0.0	12.0 (E)	
Total	240.0/	-13.3	223.3	0.0	223.3	
Bare Guidance System (IMU, PSA, PTA, & LGC)			127.3	0.0	127.3	

*No design load weight has been assigned.
/Total Control Weight specified in Letter EG-151-44-65 (February 10, 1965) from Mr. R.W. Young, ASPO, to Mr. M. Trageser, MIT/IL. See section 2-1.2.

4-4 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. Since the LEM PSA has been divided into two environmentally sealed assemblies, the power profile chart has been recalculated to reflect the dispersion of dissipated power to the PSA and Pulse Torque Assembly. The estimate for the LEM power requirements to reflect the new Design Reference Mission is currently being recalculated and will be reported in next month's report (Ref: GAEC Report LED-540-12, dated October 30, 1965).

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.

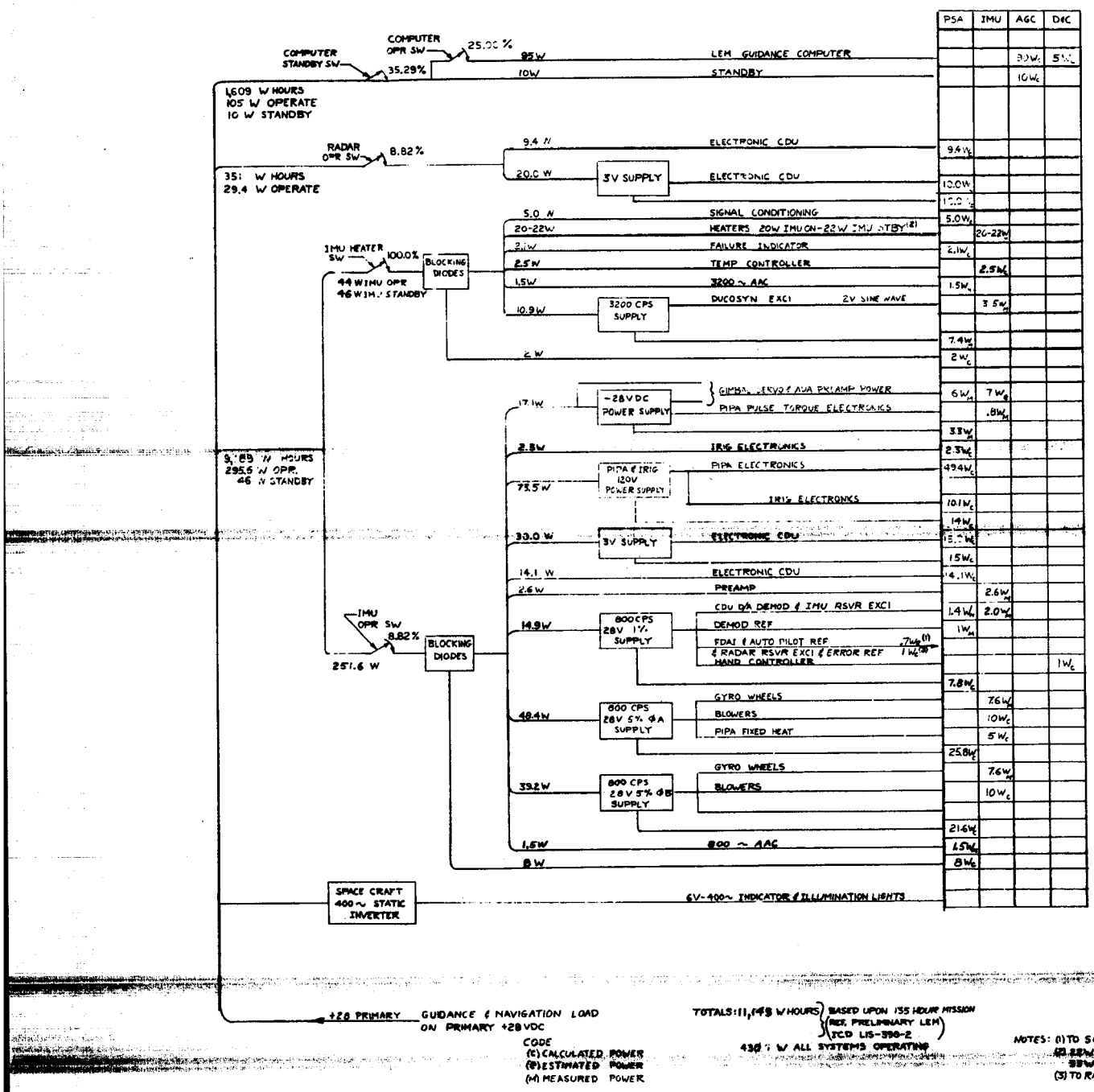

Figure 4-1. Electrical Load on Primary +28 VDC Power Supply

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

MODE	LEM G&N Activity	Energy Consumption (kwh)							
		(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 295.6 watts 11.92 hours	(5) IMU Standby 46 watts 123.15 hours	(6) Two Radar CDU Operate 29.4 watts 11.92 hours	(7) OMU (AOT) Operate Negligible watts 27.42 hours	Total
I	Inactivity 46 watts 87.40 hours	0.000	—	—	—	4.021	—	—	4.021
II	Inactivity Alignment Midcourse Measurements 430 watts 11.72 hours	—	1.231	—	3.465	—	0.345	negligible	5.041
III	Guidance During Major Event 430 watts 0.20 hours	—	0.021	—	0.059	—	0.006	—	0.086
IV	Inactivity 56 watts 20.05 hours	—	—	0.200	—	0.922	—	—	1.122
V	Inactivity 56 watts 15.70 hours	—	—	0.157	—	0.722	—	negligible	0.879
	Total 135.07 hours	0.000	1.252	0.357	3.524	5.665	0.351	negligible	11.149

Section 5

GLOSSARY AND SYSTEM DEFINITION

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 CM BLOCK II Not in CM; see Optical Subsystem.

LEM A three-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.

Condition Annunciator Assembly

CM BLOCK I Visually displays G&N system malfunctions. This function was previously part of the Map & Data Viewer.

CM BLOCK II AND LEM Not defined as yet for Block II and LEM.

Coupling Data Unit (CDU) Assembly

The CDU provides the necessary signal interface 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 tachomter, 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 Not required in Block II. These functions are now incorporated into the PSA.

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.

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 operating units: one in lower equipment bay and one on main panel between left and center couches.

CM BLOCK II Mechanically and electrically identical to Block I but smaller configuration because of smaller relays. The Block II display and keyboard controls will be hermetically sealed by encasing the unit in a container.

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 required in Block II. These functions now incorporated in the PSA.

LEM Not defined in LEM at this time.

Flight Data Book/Book of Procedures

CM BLOCK I, CM BLOCK II, AND LEM Book or other form of maps, charts, procedures, instructions and the like, needed for use during the Apollo Mission.

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 Not in Block II.

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

G&N Interconnection Harness Assembly

CM BLOCK I Not required.

CM BLOCK II Consists of nine cables that electrically tie together the assemblies that make up the G&N system and interface with the spacecraft.

LEM Not required.

G&N to S/C Interface Assembly

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

CM BLOCK II Not in Block II.

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 ectronics 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 1 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.

Landing Point Designator

CM Not in CM.

LEM An optical sighting device consisting of a reticle, plane mirror, collimating lens, and a beam splitter to magnify the target area with a light-line reticle pattern.

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.

NVB and 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 A polyurethane filled aluminum skinned structure functionally similar to Block I but lighter and will provide for mounting the size 12.5 IMU. The Block II NVB is attached to the spacecraft by use of strain isolation hardmounts and will have a transition piece as a result of the re-orientation 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.

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.

PIPA Electronics Assembly

CM BLOCK I Does not exist separately in Block I.

CM BLOCK II Consists of electronics which directly support the function of the PIPA loop, including the calibration modules, containing selected components, assigned to each IMU. This sealed assembly is located in the Block I CDU location.

LEM Not required.

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 and 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. Also, electronics to support the PIPA loop have been transferred. See "PIPA Electroncs Assembly." 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. Also, the LEM PSA does not include electronics for the PIPA and IRIG loops. See "Pulse Torque Assembly."

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 to S/C 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. Weight included in PSA weight value.

CM BLOCK II AND LEM Cover required for moisture-proofing during flight. Weight is reported in PSA weight value.

Pulse Torque Assembly

CM BLOCK I Does not exist separately in Block I.

CM BLOCK II Not required.

LEM This assembly consists of electronics contained in the PIPA and IRIG loops, including the pulse torque power supply and PIPA and IRIG calibration modules. The PIPA calibration modules, containing selected components, are assigned to each IMU. This sealed assembly is located adjacent to the IMU in LEM.

Signal Conditioner Assembly

CM BLOCK I Conditions signals for telemetry.

CM BLOCK II These modules are located in the same volume now occupied by the Block I CDU's.

LEM Same as for Block I.

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