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APOLLO

GUIDANCE AND NAVIGATION

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E-1142 (Rev. 18)

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SYSTEM STATUS REPORT

March 15, 1964

[redacted]

INSTRUMENTATION LABORATORY

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ABSTRACT

The System Status Report is distributed monthly on the 15th. This month's revision (E-1142, Rev. 18) contains, in general, the following information for the Block I and 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 and Block II Command Module and LEM hardware is contained in the Glossary, section 5 of this report.

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

(1) Command Module, Block I - weights, centers of gravity, moments of inertia, and power requirements.

(2) Command Module, Block II - weights, power requirements, status of computer programs, and reliability figures.

(3) LEM - weights, power requirements, and reliability figures.

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.

COMMAND MODULE

Section 2

BLOCK I COMMAND MODULE DATA

2-1 WEIGHTS

Table 2-I presents the weights of all Block I 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.

Since most weight values now reported can be classified as only estimated weights, MIT herein affixes a prime to the (E) symbol, i.e., (E'), to denote values which MIT, for various reasons, feels to be more accurate than estimated values, yet which cannot be defined as either calculated or measured weights.

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

2-1.1 WEIGHTS STATUS REPORTING. Table 2-I also offers a comparison of present component weight values with those listed in System Status Report, E-1142 (Rev. 17), February 15, 1964. All weight changes are explained in paragraph 2-3.

2-1.2 SPEC. WEIGHT. The "Spec. Weight" column in table 2-I contains "proposed MSC weights," that is, goals set forth by MSC in a memo to MIT dated December 5, 1962.

2-1.3 DESIGN LOAD WEIGHT. The "Design Load Weight" column contains worst-estimate design weights assigned to G&N subassemblies attached to the spacecraft structure. These values are included in this report as the result of an S&ID request, at NASA Coordination Meeting No. 8, that one total weight figure for supported G&N load be assigned for structural design use. MIT herein assigns a total G&N

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

Item	Spec. Wt. 12/62 (a)	(b-a)	Status 2/64 (b)	(c-b)	Status 3/64 (c)	Design Load Wt. 3/64 (d)
LOWER EQUIPMENT BAY						
CDU & Frame Assy	6.0	+ 8.5	14.5	0.0	14.5(M)	17.2
Optical Subsystem						
SXT	12.0	+ 2.6	14.6	+0.5	15.1(C)	
SCT	9.0	+ 4.8	13.8	+0.5	14.3(C)	
Optical Base & Gearing	14.0	+ 2.7	16.7	0.0	16.7(E)	
Optical Eyepieces						
SXT	2.0	+ 1.6	1.3	0.0	1.3(E)	154.2
SCT			2.3	0.0	2.3(E)	
IMU	40.0	+20.2	60.2	0.0	60.2(M)	
NVB & Shock Mounts	16.0	+ 9.0	25.0	0.0	25.0(E)	
Bellows Assy	8.0	+ 5.5	13.5	0.0	13.5(M)	
G&N Interconnection Assy	30.0	+13.2	35.2	-5.2	30.0(C)	42.8
G&N to S/C Interface Assy			8.0	0.0	8.0(E)	
D&C Nav Station						
IMU Control Panel	30.3	- 7.4	2.4	0.0	2.4(M)	6.8
D&C Electronics			2.9	0.0	2.9(M)	7.7
Control Electronics			2.9	0.0	2.9(E)	
Optical Shroud			5.2	0.0	5.2(M)	4.2
G&N Ind Cont Panel			9.5	0.0	9.5(M)	13.2
D&C/AGC	15.0	+ 5.6	20.6	0.0	20.6(M)	19.4
MDV (includes 1 film)	5.0	+ 2.7	7.7	0.0	7.7(C)	10.0
AGC (no spares)	80.0	-10.0	70.0	0.0	70.0(E)	126.4
PSA	25.0	+34.4	59.4	+0.4	59.8(C)	65.0
Signal Conditioner Assy	0.0	+ 0.0	0.0	+4.6	4.6(E)	
Coolant Hoses	0.0	+ 1.0	1.0	0.0	1.0(E)	

(cont)

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

Item	Spec. Wt. 12/62 (a)	(b-a)	Status 2/64 (b)	(c-b)	Status 3/64 (c)	Design Load Wt. 3/64 (d)
MAIN PANEL AREA						
D&C/AGC	5.0	+15.5	20.5	0.0	20.5(M)	17.2
D&C/NAV	8.0	- 8.0	--	--	--	--
LOOSE STORED ITEMS						
Eye Relief Eyepieces	--	+ 1.5	1.5	0.0	1.5(E)	
Film Cartridges (4)	--	+ 2.4	2.4	0.0	2.4(E)	
Horizon Photometer	--	+ 3.6	3.6	0.0	3.6(E)	
TOTAL	305.3	109.4	414.7	+0.8	415.5	*484.1
List of Possible Spares for Block I						*Does not include loose stored items
AGC Spare Logic Tray	20.0	+58.8	25.0	0.0	25.0(E)	
AGC Spare Memory Tray			34.6	0.0	34.6(E)	
PSA Spare (Unique) Modules			16.7	0.0	16.7(E)	
CDU Spare			2.5	0.0	2.5(E)	
Spare Relay & Diode Module	--	+ 0.3	0.3	0.0	0.3(E)	

design load weight, in table 2-I, which does not include items termed "loose stored items." The breakdown of this total weight into the individual items of column "d" is typical only.

2-2 BLOCK I SPARES

The Block I weight status summerized in table 2-I separates the weight of possible spares from the main body of the table. This was done in recognition of the Development Test Plan activities now under way at S&ID which are defining Block I G&N usage. Since any spacecraft flights involving Block I G&N hardware will be unmanned or of only limited duration, the need for carried spares is doubtful. (Block II G&N will carry no spares in any event.) Because Block I was originally designed to use spares for inflight repair, the weight of possible spares is listed separately for information in table 2-I.

2-3 REPORTED WEIGHT CHANGES

Weight changes since last month's report, E-1142 (Rev. 17), February 15, 1964, are explained below. See Appendix A which presents, in chart form, the weight change history of the Command Module G&N equipment.

2-3.1 SXT AND SCT. The 0.5-lb weight increase for both the SXT and SCT is based upon Kollsman Instrument Corporation's report "Attachment A" dated February 4, 1964, which is a revision to KIC's "Apollo Optical Unit Center of Gravity Report" dated December 15, 1963.

The SXT Shaft Gear Box Assembly (P/N 1011705), the SXT Index Head Assembly (P/N 1011701), the Servo Motor Tachometer Generator (P/N 1010610), and the SCT Shaft Drive Gear Box Assembly (P/N 1011703) were all found to weigh more then previous estimates.

2-3.2 G&N INTERCONNECTION ASSY. The 5.2-pound weight decrease results from a partial weighing of the AGE 4 G&N Interconnection Assembly.

2-3.3 SIGNAL CONDITIONER ASSY. This assembly has been added to Block I to provide signal conditioning for telemetry in the early R&D flights using Block I G&N. Its weight represents the various signal conditioning modules, a mounting frame and hardware, wiring, and connectors. Changes will possibly be required for the various missions. These changes will be made in the appropriate modules and in the frame interwiring. It is assumed that this can be done within the same envelope using the same module mounting interface from one system to the next.

2-3.4 PSA. The 0.4-pound increase results from the added power supplies required for the Signal Conditioning Assembly. They are located in tray 10 and consist of three isolated power supplies: (1) The 2.5 VDC Signal Conditioner Bias Supply provides a bias for those signal conditioner outputs that can range between -2.5 V and +2.5 V. (2) The 28 VDC Pressure Transducer Supply provides power for the IMU Pressure Transducer. (3) The 20 VDC Signal Conditioner Supply provides power for all the active signal conditioners.

2-4 IDENTIFICATION OF BLOCK I G&N EQUIPMENT BY ASSEMBLY DRAWING NUMBERS

In response to an NAA letter (64 MA 2032) to MIT/IL that Block I G&N equipment nomenclature (as called out in E-1142) be identified by assembly drawing numbers, Appendix B was added to this report. Appendix B shows the Block I Installation List which identifies Block I flight hardware by assembly drawing numbers. To this list MIT has added the E-1142 G&N equipment nomenclature for identification purposes. This additional information should in no way be considered as an official part of NASA drawing number 1014999.

2-5 CENTERS OF GRAVITY

Table 2-II presents the centers of gravity of each weight component or packaged assembly, determined with respect to the basic X, Y, Z, axes of the Command Module. Center of gravity values are given to the nearest tenth of an inch.

2-6 MOMENTS OF INERTIA

Table 2-II also presents the moments of the inertia of each weight component or packaged assembly, determined about each of the component axes which (1) run through the center of gravity of the component and (2) are parallel to the basic X, Y, and Z axes of the Command Module.

2-7 COMMAND MODULE POWER REQUIREMENTS

The power requirements of the Command Module G&N 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 14-day lunar orbit mission as defined by S&ID for power profile computation (Ref: S&ID letter 63 MA 7332).

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-II. Block I Command Module Center of Gravity and Moment of Inertia Data

Item	Weight (lbs)	Centers of Gravity (inches)			Moments of Inertia ($lb\text{-}in^2$)		
		X	Y	Z	Ixx	Iyy	Izz
LOWER EQUIPMENT BAY							
CDU & Frame Assy	14.5	63.5	-14.4	35.8	45	410	410
Optical Subsystem							
SXT	15.1*	70.5	- 3.5	34.7			
SCT	14.3*	70.5	5.5	34.7			
Opt. Base & Gearing	16.7	67.9	0.0	30.7			
Optical Eyepieces							
SXT	1.3	65.1	- 3.5	26.2	5	10	5
SCT	2.3	65.1	4.5	26.2	10	10	10
IMU	60.2	56.6	0.0	41.7	1186	1450	1438
NVB & Shock Mounts	25.0	64.3	- 0.1	41.3	3270	4050	5210
Bellows Assy	13.5						
G&N Interconnection Assy	30.0*						
G&N to S/C Interface Assy	8.0						
D&C/NAV Station							
IMU Cont Panel	2.4	74.0	-15.4	30.9	15	22	24
D&C Electronics	2.9	49.5	- 9.6	39.6	20	22	9
Control Electronics Assy	2.9	63.1	10.7	34.9	9	15	8
Optical Shroud	5.2	66.8	0.0	28.9	257	108	413
G&N Ind. Control Panel	9.5	54.1	0.1	33.9	460	120	580
D&C/AGC	20.6						
MDV (Includes 1 film)	7.7	73.5	- 4.5	31.0			
AGC (no spares)	70.0	37.8	1.3	46.1	4980	3990	1710
Spare Tray (logic)	25.0	38.2	- 7.7	45.3	1290	1360	140

(cont)

Table 2-II. Block I Command Module Center of Gravity and Moment of Inertia Data (cont)

Item	Weight (lbs)	Centers of Gravity (inches)			Moments of Inertia ($lb-in^2$)		
		X	Y	Z	Ixx	Iyy	Izz
PSA	59.8*	45.0	- 1.1	41.5	3940	1460	2620
Signal Conditioner Assy	4.6*						
Coolant Hoses	1.0						
MAIN PANEL AREA							
D&C/AGC	20.5						
LOOSE STORED ITEMS							
Eye Relief Eyepieces (2)	1.5	(SCT, 4-5/8" x 2 1/2" dia.; SXT 3" x 2-1/4" dia.)					
Film Cartridges (4)	2.4	(Each cartridge, 1-1/2 x 3 x 6 inches)					
AGC Spare Mem. Tray	34.6						
CDU Spare Gearbox	2.5	(approximately 6.0 x 1-13/16 x 5 1/2 inches)					
Spare Relay & Diode Mod.	0.3	(3 x 3 x 2 inches)					
Horizon Photometer	3.6	(6 x 6 x 3 inches)					
PSA Loose Spares	16.7						

*These values represent changes since the last report, E-1142 (Rev. 17), dated February 15, 1964.

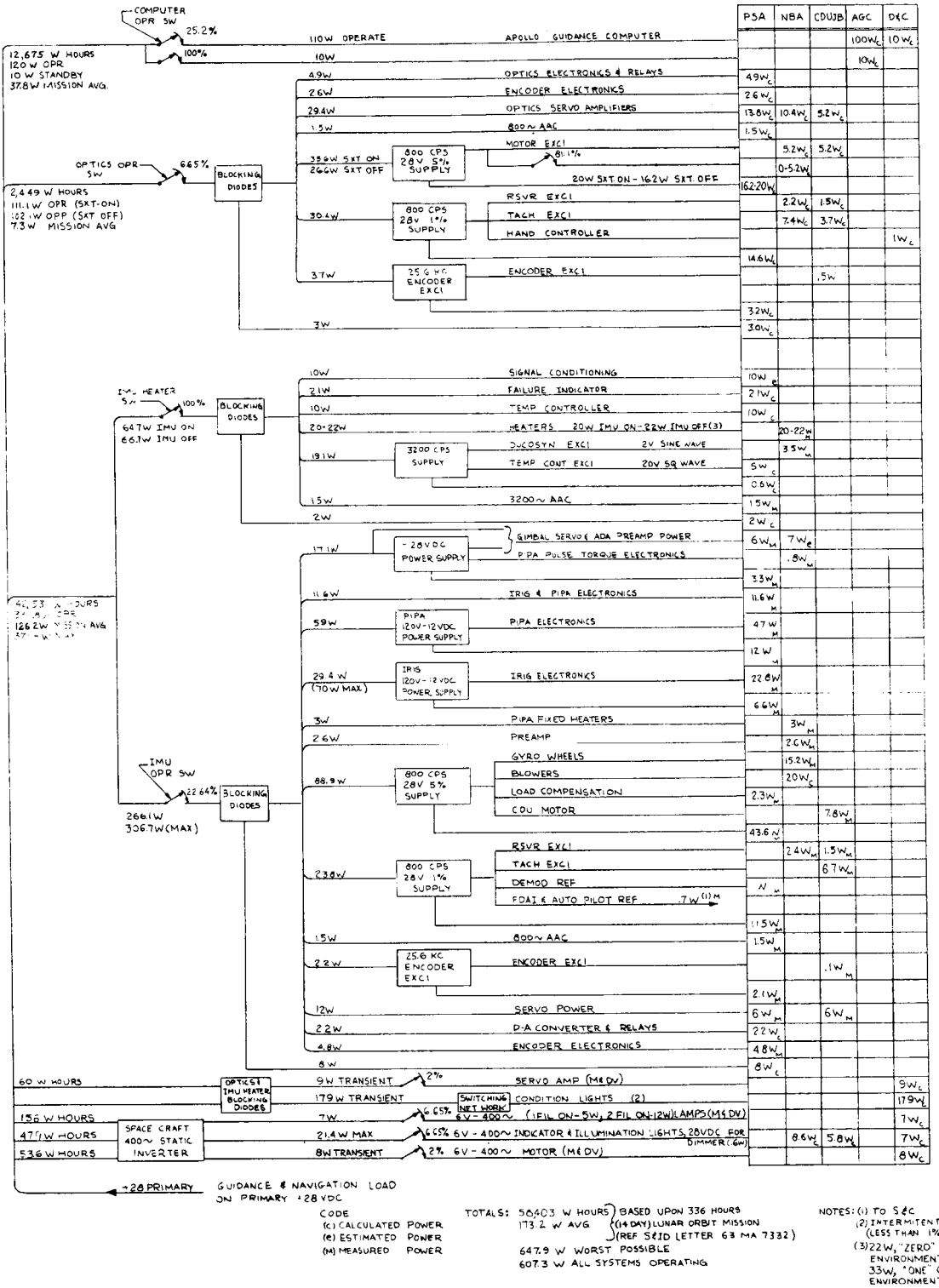


Figure 2-1. Electrical Load on Primary +28 VDC Power Supply

Table 2-III. Nominal Power Dissipation (watts) vs G&N Activity

MODE	G&N Activity (power levels)	NBA		CDUJB	PSA		AGC	Thermal Load On S/C Coolant	D&C and S&C	Electrical Load
		IMU	OBA		IMU	OBA				
A	IMU & AGC Operate (1, 4)	74.5	0	22.1	233.5	0	110	440.1	10.7	450.8
B	IMU Alignment (1, 2, 4, 6)	74.5	39	44	233.5	63.6	110	564.6	42.7	607.3
C	Low-Orbit Navigation (1, 3, 4, 6)	74.5	33.8	44	233.5	59.8	110	555.6	42.7	598.3
D	Standby & Computing (1, 5)	25.5	0	0	41.2	0	110	176.7	10	186.7
E	Midcourse Navigation (1, 2, 5, 6)	25.5	30	21.9	41.2	63.6	110	301.2	42	343.2
F	IMU & AGC Standby (5, 7)	25.5	0	0	41.2	0	10	76.7	0	76.7
G	IMU Operate & AGC Standby (4, 7)	74.5	0	22.1	233.5	0	10	340.1	0.7	340.8

1.	AGC	120 watts
2.	Optics, SXT on	111.1 watts
3.	Optics, SXT off	102.1 watts
4.	IMU Operate	330.8 watts
5.	IMU Standby	66.7 watts
6.	Display and Control	45.4 watts
7.	AGC Standby	10 watts

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 14-day mission submitted by S&ID in S&ID letter 63 MA 7332. This column also indicates the power consumption and operating time for each specific activity. The top row indicates the various power levels along with the power consumption and operating time of each power level.

Table 2-IV. Block I Command Module Power Profile for 14-Day Lunar Orbit Mission

MODE	G&N Activity	Energy Consumption (kwh)							
		(1) AGC Operate 120 watts 84.67 hrs	(2) Optics SXT on 111.1 watts 18.53 hrs	(3) Optics SXT off 102.1 watts 3.83 hrs	(4) IMU Operate 330.8 watts 76.09 hrs	(5) IMU Standby 66.7 watts 260.32 hrs	(6) Display & Controls 45.4 watts 22.36 hrs	(7) AGC Standby 10.0 watts 251.74 hrs	Total
A	IMU & AGC Operate 450.8 watts, 56.71 hrs	6.805	--	--	18.759	--	--	--	25.564
B	IMU Alignment 607.3 watts, 8.20 hrs	0.984	0.911	--	2.712	--	0.372	--	4.979
C	Low-Orbit Navigation 598.3 watts, 3.83 hrs	0.459	--	0.391	1.266	--	0.173	--	2.289
D	Standby & Computing 186.7 watts, 5.60 hrs	0.672	--	--	--	0.373	--	--	1.045
E	Midcourse Navigation 343.2 watts, 10.33 hrs	1.239	1.147	--	--	0.689	0.468	--	3.543
F	IMU & AGC Standby 76.7 watts, 244.39 hrs	--	--	--	--	16.300	--	2.443	18.743
G	IMU Operate & AGC Standby 340.8 watts, 7.35 hrs	--	--	--	2.431	--	--	0.073	2.504
	TOTAL	10.159	2.058	0.391	25.168	17.362	1.013	2.516	58.667

BLOCK II

COMMAND MODULE

Section 3

BLOCK II COMMAND MODULE DATA

3-1 RELIABILITY

The following numbers do not assume the use of inflight spares or repair. The estimated Command Module G&N reliability is based on the 138-hour mission as defined in the Lunar Landing Mission Design Plan.

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

Subsystem	Operating Time (hrs) Full Power	Probability of Mission Success
IMU	31	0.99575
AGC (2)	19*	0.999913
DSKY	19	0.999954
PSA	31*	0.994
CDU (5)	31	0.9942
Optics	18	0.9985
Total G&N System		0.9824

*Certain assemblies function continuously.

3-2 WEIGHTS

Table 3-II presents the weights of all Block II equipment. Refer to section 2-1 for a general explanation of weight reporting.

3-3 REPORTED WEIGHT CHANGES

Weight changes shown in column (c - b) of table 3-II are explained below.

3-3.1 SXT AND SCT. See section 2-3.1.

3-3.2 G&N INTERCONNECTION ASSY. See section 2-3.2.

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

ITEM	Spec. Wt. 12/62 (a)	(b-a)	Status 2/64 (b)	(c-b)	Status 3/64 (c)	Design Load Wt. 3/64 (d)
LOWER EQUIPMENT BAY						
CDU & Frame Assy	6.0	+9.0	15.0	0.0	15.0 (E)	17.2
Optical Subsystem						
SXT (incl. photometer)	12.0	+6.2	18.2	+0.5	18.7 (C)	
SCT	9.0	+4.8	13.8	+0.5	14.3 (C)	
Optical Base & Gearing	14.0	+2.7	16.7	0.0	16.7 (E)	
Optical Eyepieces						
SXT	2.0	+1.6	1.3	0.0	1.3 (E)	154.2
SCT			2.3	0.0	2.3 (E)	
IMU	40.0	+2.0	42.0	0.0	42.0 (E)	
NVB & Shock Mounts	16.0	+6.0	22.0	0.0	22.0 (E)	
Bellows Assy	8.0	+5.5	13.5	0.0	13.5 (M)	
G&N Interconnection Assy	30.0	+13.2	35.2	-5.2	30.0 (E)	42.8
G&N to S/C Interface Assy			8.0	0.0	8.0 (E)	
D&C Nav Station						
D&C Electronics	30.3	-9.6	1.5	0.0	1.5 (E)	7.7
Control Electronics			2.9	0.0	2.9 (E)	
Optical Shroud			5.2	0.0	5.2 (E)	4.2
G&N Ind Cont Panel			11.1	0.0	11.1 (E)	13.2
D&C/AGC	15.0	+5.6	20.6	0.0	20.6 (M)	19.4
MDV (including 2 films)	5.0	+3.3	8.3	0.0	8.3 (E)	10.0
AGC (2 complete computers)	80.0	+12.5	84.0	0.0	84.0 (E)	126.4
AGC Covers (2)			8.5	0.0	8.5 (E)	
PSA	25.0	+20.1	41.6	0.0	41.6 (E)	65.0
PSA Cover			3.5	0.0	3.5 (E)	
Coolant Hoses	0.0	+1.0	1.0	0.0	1.0 (E)	

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

Item	Spec. Wt. 12/62 (a)	(b-a)	Status 2/64 (b)	(c-b)	Status 3/64 (c)	Design Load Wt. 3/64 (d)
MAIN PANEL AREA						
D&C/AGC	5.0	+15.5	20.5	0.0	20.5(M)	17.2
D&C/NAV	8.0	- 8.0	--	--	--	--
LOOSE STORED ITEMS						
Eye Relief Eyepieces	--	+ 1.5	1.5	0.0	1.5(E)	
Film Cartridges (3)	--	+ 1.8	1.8	0.0	1.8(E)	
TOTAL	305.3	94.7	400.0	-4.2	395.8	*477.3
						*Minus loose stored items

3-4 STATUS OF COMMAND MODULE AGC PROGRAMS

Table 3-III lists current Command Module memory estimates and the status of AGC programs. The status of LEM AGC programs is not reported at this time.

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 3-III. Current Memory Estimates and the Status of Command Module AGC Programs

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	(3)	500*	250*
G&N System Exerciser	(2)	650*	400*
Display, Keyboard, and Telemetry	(5)	1500	1500
Input/Output Control	(4)	1500*	1092*
Midcourse & Orbital Navigation	(4)	2000	1500
Midcourse & Orbital Guidance	(3)	500	500
Prelaunch Platform Alignment	(5)	400	350*
In-Flight Platform Alignment	(2)	1024*	900
Re-entry Control	(4)*	1800*	1200*
Injection and De-Boost	(4)*	1000	400
Sub-total		12984	10202
Restart**	(2)	2000	1500
Aim-Point Determination & Abort**	(1)	4000	2000
Totals		18984	13702

*These items have changed since the last report, E-1142 (Rev. 17), dated February 15, 1964.

**Not previously estimated since studies had not progressed to the point where intelligent estimates could be made.

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 present the magnitude and location of dissipated power values on a subassembly level. This chart assumes a 14-day lunar orbit mission as defined by S&ID for power profile computation (Ref: S&ID letter 63 MA 7332).

Major changes to Block II power requirements, as compared to Block I requirements, are due to the use of two computers and electronic CDU's in the Block II system.

A chronological time line and power profile for the Block II Command Module is presented in Appendix C.

COMMAND MODULE

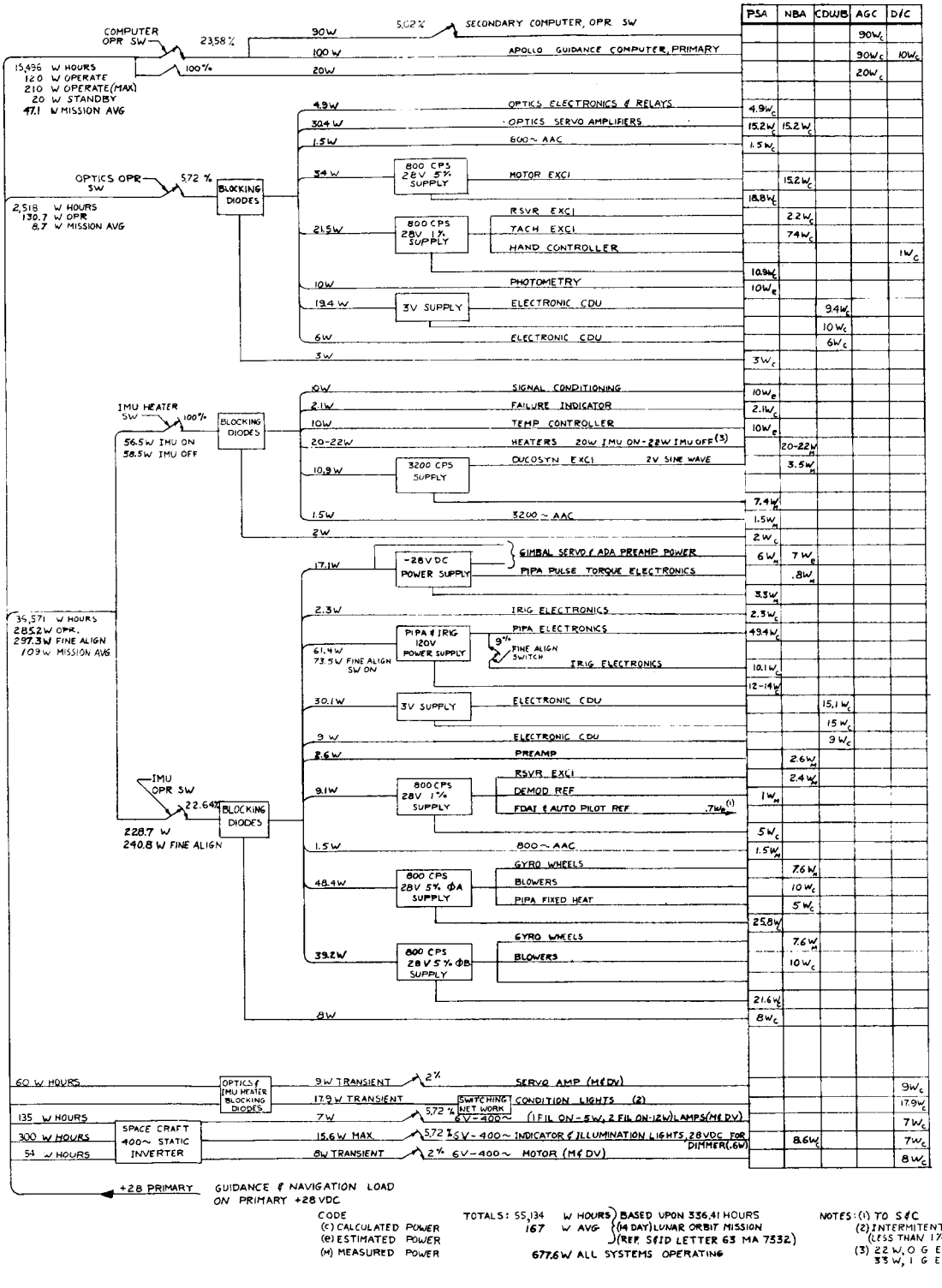


Figure 3-1. Electrical Load on Primary +28 VDC Power Supply

LUNAR EXCURSION MODULE

Section 4

LUNAR EXCURSION MODULE DATA

4-1 RELIABILITY

The numbers in Table 4-I do not assume the use of in-flight spares or repair. LEM reliability calculations are based on the guidance and navigation mission profile as directed by MSC for reliability planning.

Table 4-I. Reliability (as of 3/15/64)

Subsystem	Operating Time (hrs)	Probability of Mission Success
IMU	7	0.999
AGC	7	0.99769
PSA	7	0.99896
CDU (5)	7	0.998965
OMU	1	0.999957
Total G&N System		0.9946

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 and 2-1.1.

Column (a), "Target Weight," was taken from GAEC LMD 490-39, Enclosure 1, submitted to MIT at a weights review meeting on September 10, 1963. GAEC reported that G&N weights associated with D&C will be reported by them as part of the total spacecraft D&C. Therefore, target weights were not given by GAEC to supply the five items denoted by asterisks in column (a).

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

4-3 POWER REQUIREMENTS

The estimate for LEM power and energy consumption shown in figure 4-1 is updated this month and is based upon recent command module G&N Block II data and a submission by GAEC of preliminary ICD LIS-390-2 which contains new changes in the LEM Electrical Load Analysis Form.

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

Item	Target Wt. 8/63 (a)	(b-a)	Status 2/64 (b)	(c-b)	Status 3/64 (c)	Design Load Wt. 3/64 (d)
CDU's	*		15.0	0.0	15.0(E)	**
Telescope and All Eyepieces	12		24.5	0.0	24.5(E)	
Navigation Base	4		--	--	--	
Eye Register for Reticule	*		2.0	0.0	2.0(E)	
Two-Digit Readout for Reticule	*		5.0	0.0	5.0(E)	
IMU	58		42.0	0.0	42.0 (E)	
AGC/PSA Interconnection Assy	15		10.0	0.0	10.0(E)	
AGC Display and Controls	*		19.5	0.0	19.5(E)	
Other Display and Controls	*		15.0	0.0	15.0(E)	
Book of Procedures, etc.	2		2.0	0.0	2.0(E)	
AGC	60		41.5	0.0	41.5(E)	
AGC Cover	*		4.3	0.0	4.3(E)	
PSA	35		24.8	0.0	24.8(E)	
PSA Cover	*		2.4	0.0	2.4(E)	
Cold Plate	5		--	--	--	
TOTAL	191 Plus * Items not yet given		208.0	0.0	208.0	
Bare Guidance System (IMU, PSA, and computer): ** No design load weight has been assigned			108.3	0.0	108.3	

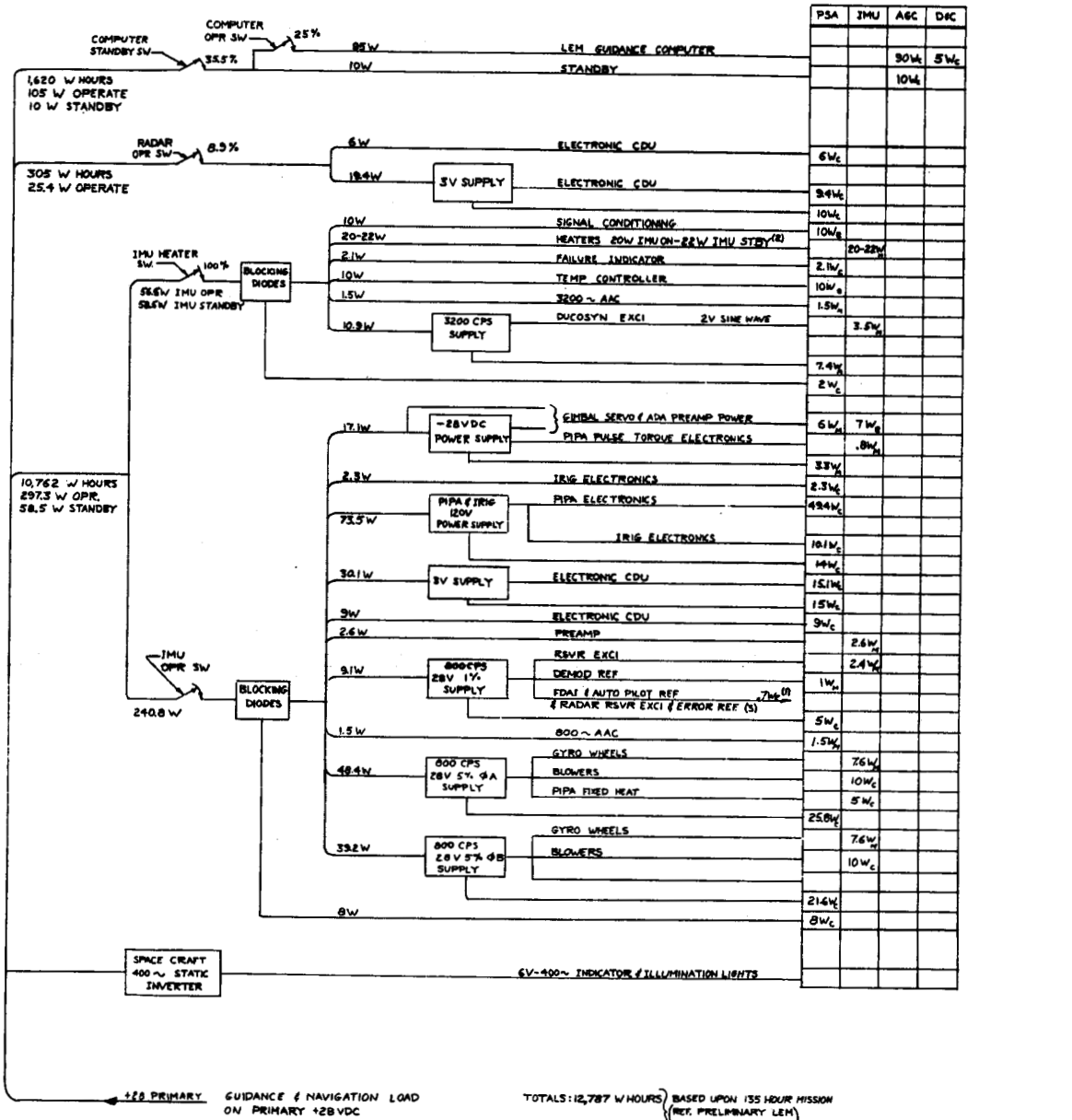


Figure 4-1. Electrical Load on Primary +28 VDC Power Supply

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 two trays containing replaceable electronic modules, the AGC end connector, and toe plate. Does not include the necessary cold plate or the G&N to S/C Interface Assembly which is located in the adjacent area. Space exists for carrying an extra spare pair of AGC trays. These would not function in this spares location but could interchange with faulty trays in the active position. The spare trays are not included in this accounting.

CM BLOCK II Two complete and active computers each having the same functions as the Block I AGC. Consists of two wiring matrix headers mounted on each side of the cold plate. This cold plate is not included in this accounting and must be moved up from the Block I configuration location. The modules of the "X" computer mount on one of these headers, the "Y" computer on the other.

Block I and Block II AGC's are not interchangeable.

LEM A single complete flight computer having the same functions as one of the Block II computers. Unless installation constraints yet to be determined prevent it, the LEM computer will be physically identical with the Block II computers.

AGC Covers

CM BLOCK I Not required.

CM BLOCK II Two covers, one for each computer, may be required if it becomes necessary to seal the Malco connectors against moisture.

LEM Same as Block II except that there is only one cover.

AGC Spares

CM BLOCK I Spare AGC modules or trays as indicated.

CM BLOCK II No spares for AGC in Block II.

LEM No spares for AGC in LEM.

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.

Bellows Assembly

CM BLOCK I AND CM BLOCK II Flexible pressure seal between CM structure and optical subsystem on NAV BASE for penetration of pressure hull with optics.

LEM Not identified separately in LEM. Is included in LEM as part of the AOT.

Book of Procedures

CM Not in CM; see MDV.

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

Coupling Data Unit (CDU) and Frame 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 framework. 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 is located in same volume as Block I CDU's.

Changes in resolver synchro characteristics and mode controls make Block I and II CDU's noninterchangeable.

LEM Interchangeable with CM Block II CDU's.

Cold Plate

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.

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.

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) three aluminum flex coolant hoses between IMU and spacecraft, optics and spacecraft, and optics and IMU, (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 AND BLOCK II 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.

LEM Identical to CM 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.

CM BLOCK II Similar but probably not identical to Block I.

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 LEM 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, and supporting hardware. Block II panel will probably contain horizon photometer controls also.

LEM Not defined at this time for 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 the G&N to S/C Interface Assembly weight or the weights of harness support brackets which are an NAA responsibility.

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 Interconnections between the spacecraft wiring channel, the computer end 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 Not all Block I systems will contain this function, but to support expected early unmanned flights using Block I this will be incorporated into later Block I systems for preflight qualification and flight test. Equipment is defined below. Block I weights assume an horizon photometer.

CM BLOCK II An earth horizon brightness photometer and automatic star tracker 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 support electronics.

LEM Not part of LEM.

Inertial Measurement Unit (IMU)

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

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

LEM Size 12.5 IMU as described above.

IMU Control Panel

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

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

LEM Not defined at this time for LEM.

Indicator Control Panel

CM BLOCK I and BLOCK H Consists primarily of controls and displays for the operation of the optics and the IMU temperature control. Includes display and control elements, panel, panelwiring, and supporting hardware.

LEM Not defined at this time for 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 eyepieces for the AOT is included as part of the AOT in this accounting.

Map and Data Viewer (MDV)

CM BLOCK I and BLOCK II Film viewer for display of maps, charts, procedures, etc. Weight includes one film cartridge for Block I MDV and tentatively two for Block II MDV.

LEM Not in LEM; see Book of Procedures.

NVB and Isolation 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 isolation 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.

LEM The need for tieing the AOT and IMU together exists but is accomplished using structure provided by the spacecraft contractor.

Optical Eyepieces

CM BLOCK I Removable SXT eyepiece and removable SCT 1- and 3-power eyepiece combination.

CM BLOCK II Same as Block I for SXT but only a 1-power eyepiece will be used with the SCT.

LEM Included as part of the AOT.

Optical Subsystem

CM BLOCK I 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
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.

CM BLOCK II Similar to Block I except for changes in the sextant to provide line-of-sight velocity control directly without CDU's. The horizon photometer and automatic star tracker are incorporated into the SXT.

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 Consists of most of the support electronics: power supplies; IMU, Optics, and CDU servos; IMU temperature control; and accelerometer and gyro pulse torquing. Consists of 10 trays with replaceable modules which plug into the PSA end connector assembly. Includes front ice plate but not the cold plate.

CM BLOCK II Similar in function to Block I but does not contain the CDU servos needed in Block I. Consists of a single plane matrix header to mount onto the cold plate with the modules plugging onto the top.

LEM See Appendix A for weight breakdown.

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.

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

LEM Not yet defined. Will probably not exist in LEM.

PSA Covers

CM BLOCK I Not required.

CM BLOCK II Protective 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 Condition signals for telemetry.

CM BLOCK II AND LEM Not used.

Two-Digit Readout for Reticule

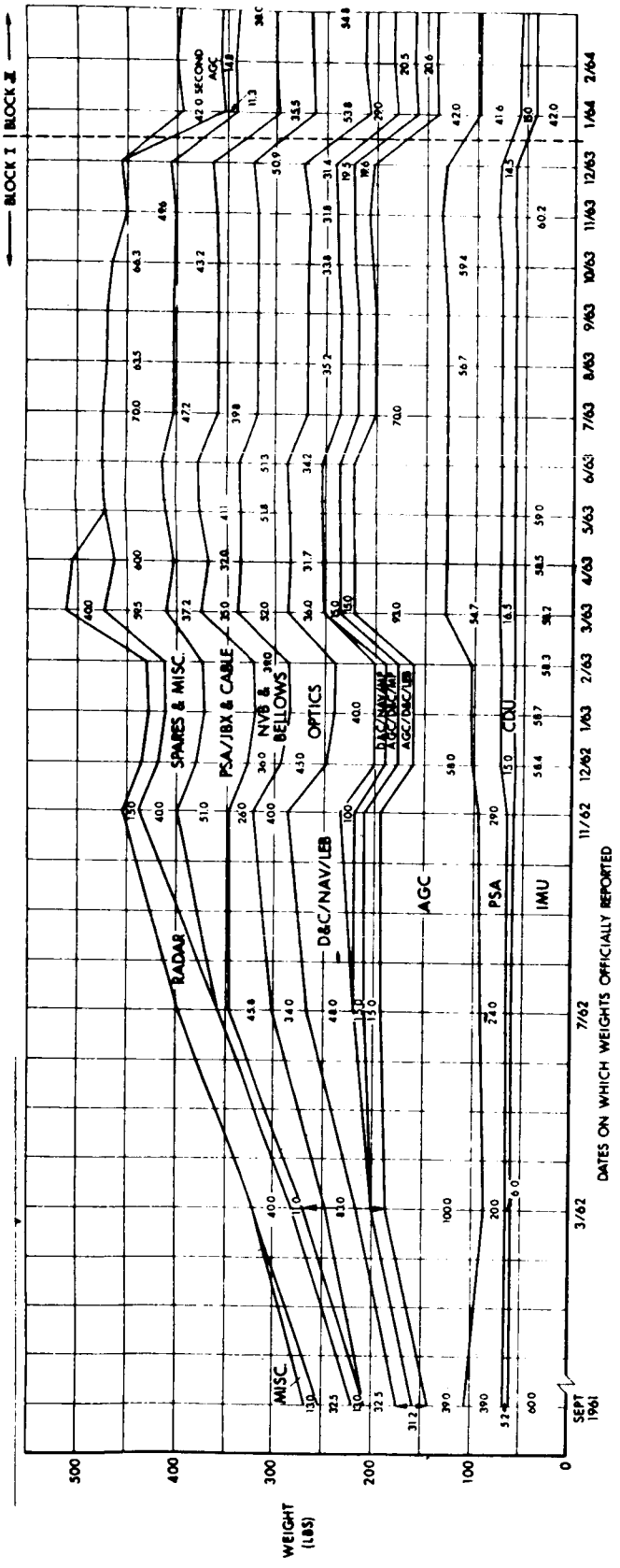
CM Not in CM.

LEM A 2-digit readout driven by the AGC from 00 to 99 to indicate range component of landing point using fixed numbered scale on window reticule.

COMMAND MODULE

Appendix A

Chronological Weight Status of G&N Equipment



Appendix B

Identification of Block I G&N Equipment by Assembly Drawing Numbers

	ITEM	QUANTITY COL. 1	QUANTITY COL. 2	QUANTITY COL. 3	PART NO.	PART NAME	ITEMS REMOVED FOR SHIPPING AND/OR INSTAL.	MONTHLY WEIGHT AND BALANCE REPORT
		SEE NOTE 4						BLOCK I
SEE NOTE 5	54	1			1001582	HOSE, FLEXIBLE, ASSY-IMU TO S/C		COOLANT HOSES
SEE NOTE 5	53	1			1001581	HOSE, FLEXIBLE, ASSY-S/C TO OPTICS BASE		COOLANT HOSES
	52		1		1003155	AGC CONNECTOR COVER PLATE		G&N TO S/C INTERFACE ASSY
	51		1		1008180	AGC TOE PLATE		AGC
	50		1		1003189	AGC END CONNECTOR ASSY		AGC
	49		1		1003197	AGC "C" ASSY		G&N TO S/C INTERFACE ASSY
	48		1		1003184	AGC "B" ASSY		AGC
	47		1		1003187	AGC "A" ASSY		AGC
SEE NOTE 3		—			1003186	AGC ASSY		
	46	1			1003540	AGC KEYBOARD & DISPLAY, MAIN PANEL		DSC AGC, MAIN PANEL
	45	1			1003524	AGC NAV DSKY ASSY		DSC AGC, LOWER EQUIP. BAY
	44	1			1007121	SIGNAL CONDITIONER ASSY		SIGNAL CONDITIONER ASSY
SEE NOTE 6	43	1			1011559	MAP & DATA VIEWER ASSY		MAP & DATA VIEWER
	42	1			1014532	OPTICS COVER		OPTICAL SHROUD
	41	1			1014502	OPTICS SHROUD		OPTICAL SHROUD
	40	1			1015003	CONTROL ELECTRONICS ASSY		CONTROL ELECTRONICS ASSY
	39	1			1014526	IMU CONTROL PANEL ASSY		IMU CONTROL PANEL
	38	1			1007059	D & C ELECTRONICS ASSY		D&C ELECTRONICS ASSY
	37	1			1014578	G & N INDICATOR & CONTROL PANEL ASSY		G&N INDICATOR & CONTROL PANEL
	36		1		1017538	CDU PANEL ASSY		CDU & FRAME ASSY
	35		5		1015500	CDU ASSY		CDU & FRAME ASSY
	34		1		1016885	CDU FRAME ASSY		CDU & FRAME ASSY
SEE NOTE 3		—			1016903	COUPLING & DISPLAY FRAME & PANEL ASSY		
	33		1		AN345C10	NUT		G&N INTERCONNECTION ASSY
	32		1		1014609	BRACKET, CLAMP		G&N INTERCONNECTION ASSY
	31		1		1010400-12	CLAMP, LOOP		G&N INTERCONNECTION ASSY
	30		2		1010400-6	CLAMP, LOOP		G&N INTERCONNECTION ASSY
	29		2		1010400-4	CLAMP, LOOP		G&N INTERCONNECTION ASSY
	28		4		1010400-3	CLAMP, LOOP		G&N INTERCONNECTION ASSY
	27		7		1010400-2	CLAMP, LOOP		G&N INTERCONNECTION ASSY
	26		1		1010400-1	CLAMP, LOOP		G&N INTERCONNECTION ASSY
	25		1		1010705	CLAMP, LOOP		G&N INTERCONNECTION ASSY
	24	1			1014606	AGE HARNESS & PSA END CONNECTOR	25,26,27,28,29,30,31,32,33	G&N INTERCONNECTION ASSY
	23		1		1008135	PSA TOE CAP		PSA
	22		1		1007160	POWER DIODE & SIGNAL COND. ELEC ASSY - TRAY #10		PSA
	21		1		1007159	OPTICAL ELECTRONICS ASSY - TRAY #9		PSA
	20		1		1007158	OPTICAL ELECTRONICS ASSY - TRAY #8		PSA
	19		1		1007157	MISC. ELECTRONICS ASSY - TRAY #7		PSA
	18		1		1007156	CDU & POWER SUPPLY ELECTRONICS ASSY - TRAY #6		PSA
	17		1		1007155	CDU & GYRO ACCEL ELECTRONICS ASSY - TRAY #5		PSA
	16		1		1007154	GYRO-ACCELEROMETER ELECTRONICS ASSY - TRAY #4		PSA
	15		1		1007153	GYRO-ACCELEROMETER ELECTRONICS ASSY - TRAY #3		PSA
	14		1		1007152	POWER SUPPLY ELECTRONICS ASSY - TRAY #2		PSA
	13		1		1007151	GIMBAL SERVO ELECTRONICS ASSY - TRAY #1		PSA
SEE NOTE 3		—			1007100	POWER SERVO ASSY		
	12	1			1000201	INERTIAL MEASUREMENT UNIT ASSY		IMU
	11			1	1011788	LONG EYE RELIEF EYEPIECE ASSY (SCI)		EYE RELIEF EYEPIECE
	10			1	1011787	LONG EYE RELIEF EYEPIECE ASSY (SXI)		EYE RELIEF EYEPIECE
	9			1	1011932	EYEPIECE (SXT), ASSY OF		SXT OPTICAL EYEPIECE
	8			1	1011960	SCT EYEPIECE ASSY		SCT OPTICAL EYEPIECE
SEE NOTE 3		—			1011000	OPTICAL UNIT		
	7		2		1899970	MOUNT-RESILIENT, FRONT ASSY (INSEP)		NVB & SHOCK MOUNTS
	6		1		1899954-002	SEAL-BELLOWS		BELLOWS ASSY
	5		1		1899954-001	SEAL-BELLOWS		BELLOWS ASSY
	4		2		1899980	BOLT-HEX HEAD		NVB & SHOCK MOUNTS
	3		1		1899978	SNUBBER, FRONT R.H. ASSY (INSEP)		NVB & SHOCK MOUNTS
	2		1		1899974	SNUBBER, FRONT L.H. ASSY (INSEP)		NVB & SHOCK MOUNTS
	1	1			1899950	NAVIGATION BASE & OPTICAL UNIT ASSY	2,3,4,5,6,7,8,9,10,11	NVB & SHOCK MTS, BELLOWS ASSY, OPTICAL SUBSYSTEM

NOTE: A third flexible hose exists with an "O" ring joint at the optics base and a quick disconnect joint at the IMU.

The APOLLO Guidance Equipment (Block I) Installation List (NASA Drawing No. 1014999) has been included in this month's report as a response to a NAA letter (64-MA-2032) to MIT-IL.

The last column, enclosed by the dashed line, has been added for information purposes only and is not included on NASA Drawing No. 1014999.

NOTES:

1. THIS DRAWING DEFINES A TOTAL G & N SYSTEM IN TERMS OF IDENTIFIABLE, SEPARATELY INSTALLED PIECES OR SEPARATE PARTS
2. EFFECTIVITY TO BE DETERMINED FROM SYSTEM IDENTIFICATION DATA LIST (SIDL), MIT REPORT E-1113
3. PART NUMBERS LISTED WITHOUT QUANTITY REQUIREMENTS ARE SHOWN FOR REFERENCE ONLY AND INDICATE NEXT ASSY OF SUB-COLUMNS
4. QUANTITIES ARE LISTED IN SUB-COLUMNS TO INDICATE DRAWING BREAKDOWN
5. ITEMS #53 & #54 ARE FURNISHED TO NAA PRIOR TO INSTALLATION AND ARE WELDED TO S/C COOLANT SYSTEM
6. MAP AND DATA VIEWER ASSY, 1011559, INCLUDES ONE CARTRIDGE ASSY, 1011420. A MAXIMUM OF FOUR ADDITIONAL CARTRIDGES WILL BE USED PER MISSION REQUIREMENTS.

FOR INFORMATION ONLY

CLASS B RELEASE TDR No. 06047 DATE 1/29/64

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	FIND NO.
		LIST OF MATERIALS	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTIONS ± DECIMALS ± ANGLES ±
DO NOT SCALE THIS DRAWING
MATERIAL
HEAT TREATMENT
FINISH
NEXT ASSY | USED ON
APPLICATION

MIT INSTRUMENTATION LAB, CAMBRIDGE, MASS. — DWG NO. — CONTRACT

DRAWN T.J. Nelson DATE 2-8-64
CHECKED
APPROVAL J.F. Kemp
APPROVAL D.G. Hoag 2-11-64
NASA APPROVAL [illegible] 2/11/64
MIT APPROVAL W.K. Hoffe 2-11-64

MANNED SPACECRAFT CENTER, HOUSTON, TEXAS

INSTALLATION LIST
APOLLO GUIDANCE EQUIPMENT
(BLOCK I)

CODE IDENT NO. | SIZE D | NASA DRAWING NO. 1014999
SCALE — WT — SHEET 1 OF 1

Appendix C

BLOCK II COMMAND MODULE POWER PROFILE

Appendix C contains a power profile for the Block II G&N System in the Command Module based upon the 14-day mission given MIT by reference S&ID letter 63 MA 7332. 17 May 1963.

The preliminary G&N power requirements have been carefully considered and the G&N system energy consumption is estimated at 55.6 kilowatt-hours.

The values in table C-I are center value (average) estimates only and do not include any safety factor for underestimating. Again it is emphasized that these are the latest expected values and should not be taken as "not to exceed" extremes.

Transient peaks of power occur at higher levels during turn-on and slewing operations. These are not included but are estimated to consume negligible energy. Data on these peaks will be forwarded when available.

The current levels of actual power are drawn from a primary 28.0 VDC source.

In order to complete the time line it was necessary to establish the G&N subsystem operating intervals required to complete necessary mission tasks. These are as follows:

(1) Alignment of IMU. Considering expected platform coarse-alignment and fine-alignment times and the time required to acquire and "mark" the necessary alignment stars, the time of fifteen (15) minutes for alignment of the platform in midcourse was established. Similar considerations were employed to define the alignment updating time interval of five (5) minutes.

(2) Optical Measurements. The time required for midcourse star-landmark measurements (Sextant) was defined to require ten (10) minutes. The time available for telescope tracking was assumed to be the time that the landmark was visible, i.e., nearly horizon to horizon passage. This was calculated to be five (5) minutes for Earth Orbit and thirteen (13) minutes for Lunar Orbit. The number and frequency of optical measurements were obtained from the Space Guidance Analysis group.

Table C-I. Block II Command Module Power Profile for 14-Day Lunar Mission

		Minutes	Hours		1	2	3	4	5	6	7	8	9	10
Mission Phase	Mission Event	Time from Launch		G&N Activity	One AGC Operate 120.0 watts	Two AGC Operate 210.0 watts	AGC Standby 20.0 watts	IMU Operate 285.2 watts	IMU Standby 58.5 watts	Display & Controls 39.6 watts	Optics Operate 130.7 watts	Watts	Hours in Operation	Kilowatt Hours Consumed
	Lift Off	0	0											
Ascent				Ascent		X		X				495.2	0.20	0.0990
	Boost Cutoff	12	0.20											
Earth Orbit Stay (3 Orbits)				Inactivity & Monitor 73.72% of the time	X			X				405.2	3.17	1.2845
				8 Landmark Trackings 15.50% of the time	X			X		X	X	575.5	0.66	0 3798
				8 Computer Updates 3.10% of the time		X		X				495.2	0.13	0.0644
				4 Alignments 7.75% of the time	X			X		X	X	575.5	0.33	0.1899
	Complete IMU Alignment	270	4.50	Computed Update		X		X				495.2	0.20	0.0990
	Start Translunar Injection	282	4.70											
Translunar Injection				Translunar Injection		X		X				495.2	0.08	0.0396
	SIV B Cutoff	286.9	4.78											
				Confirm Injection	X			X				405.2	0.63	0.2553
	1st Alignment After Injection	325	5.41											
				Alignment	X			X		X	X	575.5	0.08	0.0460
	First SXT Sighting	330	5.50											
Translunar Coast				8 SXT Sightings 20.21% of the time	X			X		X	X	575.5	1.33	0.7654
				8 Computer Updates 2.02% of the time		X		X				495.2	0.13	0.0644
				Inactivity & Monitor 75.37% of the time			X	X				305.2	4.96	1.5138
				2 Alignments 2.43% of the time	X			X		X	X	575.5	0.16	0.0921
	Complete IMU Alignment	725	12.08											
	Complete ΔV_1	740	12.33	ΔV_1	X			X				405.2	0.25	0.1013
				Inactivity & Monitor 95.82% of the time			X		X			78.5	51.82	4.0679
				11 SXT Sightings 3.38% of the time	X				X	X	X	348.8	1.83	0.6383
				11 Computer Updates 0.33% of the time		X			X			268.5	0.18	0.0491

TP 847-1

Table C-I. Block II Command Module Power Profile for 14-Day Lunar Mission (cont)

Mission Phase	Mission Event	Time From Launch: Minutes	Time From Launch: Hours	G&N Activity	1 One AGC Operate 120.0 watts	2 Two AGC Operate 210.0 watts	3 AGC Standby 20.0 watts	4 IMU Operate 285.2 watts	5 IMU Standby 58.5 watts	6 Display & Controls 39.6 watts	7 Optics Operate 130.7 watts	8 Watts	9 Hours in Operation	10 Kilowatt Hours Consumed
Trans-lunar Coast														
	Complete IMU Alignment	3985	66.41	1 Alignment 0.46% of the time	X			X		X	X	575.5	0.25	0.1439
	Complete ΔV_2	4000	66.66	ΔV_2	X			X				405.2	0.25	0.1013
				Inactivity & Monitor 90.46% of the time			X		X			78.5	11.01	0.8643
				5 SXT Sightings 6.82% of the time	X				X	X	X	348.8	0.83	0.2895
				5 Computer Updates 0.66% of the time		X			X			268.5	0.08	0.0215
	Complete IMU Alignment	4727	78.83	1 Alignment 2.05% of the time	X			X		X	X	575.5	0.25	0.1439
				Inactivity & Monitor 53.14% of the time			X	X				305.2	0.93	0.2838
				4 SXT Sightings 38.28% of the time	X			X		X	X	575.5	0 67	0.3856
				4 Computer Updates 4.00% of the time		X		X				495.2	0.07	0.0347
	Complete IMU Alignment	4835	80.58	1 Alignment 4.57% of the time	X			X		X	X	575.5	0.08	0.0460
	Complete ΔV_3	4847	80.78	ΔV_3	X			X				405.2	0.20	0.0810
	Start 1st SXT Sighting After ΔV_3	4855	80.91	Inactivity & Monitor			X	X				305.2	0.13	0.0397
				3 SXT Sightings 66.66% of the time	X			X		X	X	575.5	0.50	0.2878
				3 Computer Updates 6.66% of the time		X		X				495.2	0.05	0.0248
				Inactivity & Monitor 16.00% of the time	X			X				405.2	0.12	0.0486
	Complete IMU Alignment	4900	81.66	1 Alignment 10.66% of the time	X			X		X	X	575.5	0.08	0.0460
	Start Lunar Orbit Injection	4906.8	81.78	Computer Update		X		X				495.2	0.11	0.0545
Lunar Orbit Injection	Service Module Cutoff	4912.3	81.87	Lunar Orbit Injection		X		X				495.2	0.09	0.0446

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Table C-I. Block II Command Module Power Profile for 14-Day Lunar Mission (cont)

Mission Phase	Mission Event	Time From Launch (Minutes)	Time From Launch (Hours)	G&N Activity	1 One AGC Operate 120.0 watts	2 Two AGC Operate 210.0 watts	3 AGC Standby 20.0 watts	4 IMU Operate 285.2 watts	5 IMU Standby 58.5 watts	6 Display & Controls 39.6 watts	7 Optics Operate 130.7 watts	8 Watts	9 Hours in Operation	10 Kilowatt Hours Consumed
Lunar Orbit Coast (20 Orbits)	Service Module Cutoff	4912.3	81.87											
				1 Alignment 3.75% of the time	X			X		X	X	575.5	0.08	0.0460
				Inactivity & Monitor 63.38% of the time	X			X				405.2	1.35	0.5470
				3 Landmark Trackings 30.51% of the time	X			X		X	X	575.5	0.65	0.3741
				3 Computer Updates 2.35% of the time		X		X				495.2	0.05	0.0248
	Begin Star Occultation Sightings	5040	84.00	18 once per orbit star occultation sightings 4% of the time	X				X			178.5	1.46	0.2606
				18 Computer Updates 0.82% of the time		X			X			268.5	0.30	0.0806
				Inactivity & Monitor 95.18% of the time			X		X			78.5	34.74	2.7270
	Start First Alignment After Star Occultation Sightings	7230	120.50	1 Alignment	X			X		X	X	575.5	0.25	0.1439
	Complete IMU Alignment	7245	120.75	Inactivity & Monitor			X	X				305.2	0.23	0.0702
	Start Landmark Tracking	7259	120.98	1 Landmark Tracking	X			X		X	X	575.5	0.21	0.1209
	Finish Landmark Tracking	7272	121.19	1 Computer Update		X		X				495.2	0.01	0.0050
	Complete AGC Update	7273	121.20	Inactivity & Monitor			X	X				305.2	0.16	0.0488
	Start SXT Inspection of Site	7283	121.36	Inspect Site with SXT	X			X		X	X	575.5	0.17	0.0978
	Finish SXT Inspection of Site	7293	121.53	1 Computer Update		X		X				495.2	0.01	0.0050
	Complete AGC Update	7294	121.54	Inactivity & Monitor	X			X				405.2	0.12	0.0486
	Begin IMU Alignment	7301	121.66	1 Alignment	X			X		X	X	575.5	0.08	0.0460
	Complete IMU Alignment	7306	121.74	Inactivity & Monitor			X	X				305.2	0.09	0.0275
	Start Landmark Tracking	7311	121.83	1 Landmark Tracking	X			X		X	X	575.5	0.21	0.1209
	Finish Landmark Tracking	7324	122.04											

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Table C-I. Block II Command Module Power Profile for 14-Day Lunar Mission (cont)

Mission Phase	Mission Event	Time From Launch (Minutes)	Time From Launch (Hours)	G&N Activity	1 One AGC Operate 120.0 watts	2 Two AGC Operate 210.0 watts	3 AGC Standby 20.0 watts	4 IMU Operate 285.2 watts	5 IMU Standby 58.5 watts	6 Display & Controls 39.6 watts	7 Optics Operate 130.7 watts	8 Watts	9 Hours in Operation	10 Kilowatt Hours Consumed
Lunar Orbit Coast (20 Orbits)	Finish Landmark Tracking	7324	122.04											
				1 Computer Update		X		X				495.2	0.01	0.0050
	Complete AGC Update	7325	122.05											
				Inactivity & Monitor	X			X				405.2	0.14	0.0567
	Begin IMU Alignment	7333	122.19											
				2 Alignments	X			X		X	X	575.5	0.16	0.0921
	Complete IMU Alignment	7342	122.36											
				LEM Checkout & Separate from C.M.	X			X				405.2	0.51	0.2067
Injection Into Equal Period Orbit	Begin LEM Inspection to "Equal Period Orbit"	7372	122.87											
				Injection into "Equal Period Orbit"	X			X				405.2	0.01	0.0040
Transfer to 50,000 feet	Begin Transfer to 50,000 ft.	7372.5	122.88											
				Radar Track of LEM During Transfer to 50,000 ft.	X			X		X	X	575.5	0.49	0.2820
	Begin "Equal Period Orbit" Stay	7401.7	123.37											
				Inactivity & Monitor 84.55% of the time	X			X				405.2	5.20	2.1070
Equal Period Orbit Stay														
				3 Landmark Trackings 10.57% of the time	X			X		X	X	575.5	0.65	0.3741
				3 Computer Updates 0.81% of the time		X		X				495.2	0.05	0.0248
				3 Alignments 4.06% of the time	X			X		X	X	575.2	0.25	0.1439
Perilune Retro (50,000 to 1,000) ft.	Begin Perilune Retro	7770.2	129.52											
				Perilune Retro	X			X				405.2	0.10	0.0405
Hover, Translation, & Touchdown	Begin Hover Translation & Touchdown	7776.5	129.62											
				Hover, Translation and Touchdown	X			X				405.2	0.04	0.0162
LEM Lunar Surface Stay	Begin LEM Lunar Surface Stay	7778.7	129.66											
				Inactivity & Monitor 98.44% of the time	X			X				405.2	31.50	12.7638
				2 Alignment 1.56% of the time	X			X		X	X	575.5	0.50	0.2877
~~Lunar Ascent~~ to Circular Orbit at ~~50,000 ft.~~	Begin Lunar Ascent to Circular Orbit at 50,000 ft.	9698.7	161.66											
				Lunar Ascent to Circular Orbit at 50,000 ft.	X			X				405.2	0.07	0.0284
Ascent Transfer to 80 NM	Begin Ascent Transfer to 80 NM	9702.9	161.73											
				Inactivity & Monitor	X			X				405.2	0.06	0.0243
	Start Landmark Tracking	9707.9	161.79											
				1 Landmark Tracking	X			X		X	X	575.5	0.21	0.1208
	Finish Landmark Tracking	9721	162.00											
				1 Computer Update		X		X				495.2	0.01	0.0050
	Complete AGC Update	9722	162.01											

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Table C-I. Block II Command Module Power Profile for 14-Day Lunar Mission (cont)

Mission Phase	Mission Event	Time From Launch (Minutes)	Time From Launch (Hours)	G&N Activity	1 One AGC Operate 120.0 watts	2 Two AGC Operate 210.0 watts	3 AGC Standby 20.0 watts	4 IMU Operate 285.2 watts	5 IMU Standby 58.5 watts	6 Display & Controls 39.6 watts	7 Optics Operate 130.7 watts	8 Watts	9 Hours in Operation	10 Kilowatt Hours Consumed
Ascent Transfer to 80 NM	Complete AGC Update	9722	162.01											
	Begin Period of LEM Trackings	9760.9	162.70	Inactivity & Monitor	X			X				405.2	0.69	0.2796
Rendezvous				Inactivity & Monitor 84.41% of the time	X			X				405.2	6.93	2.8080
				4 LEM Trackings 10.59% of the time	X			X		X	X	575.5	0.87	0.5007
				4 Computer Updates 0.85% of the time		X		X				495.2	0.07	0.0347
				4 Alignments 4.05% of the time	X			X		X	X	575.5	0.33	0.1899
	LEM Docking	10252.9	170.90	36 once per orbit Star Occultation Sightings 4% of the time	X				X			178.5	3.00	0.5355
				36 Computer Updates 0.80% of the time		X			X			268.5	0.60	0.1611
				Inactivity & Monitor 95.20% of the time			X		X			78.5	71.33	5.6000
	Start 1st Alignment After Star Occultation Sightings	14750	245.83	2 Alignments 18.85% of the time	X			X		X	X	575.5	0.33	0.1899
Lunar Orbit Coast (38 Orbits)				Inactivity & Monitor 81.14% of the time	X			X				405.2	1.42	0.5754
	Start Landmark Tracking	14855	247.58	1 Landmark Tracking	X		X	X			X	575.5	0.21	0.1209
	Finish Landmark Tracking	14868	247.80	1 Computer Update		X		X				495.5	0.01	0.0050
	Complete AGC Update	14869	247.81	Inactivity & Monitor	X			X				405.2	0.69	0.2796
	Begin IMU Alignment	14910	248.50	1 Alignment	X			X		X	X	575.5	0.08	0.0460
	Complete IMU Alignment	14915	248.58	Inactivity & Monitor	X			X				405.2	0.07	0.0284
	Start Last Computer Update Before Injection	14917	248.65	Computer Update		X		X				495.2	0.25	0.1238
Transearth Injection	Begin Transearth Injection	14934.0	248.90	Transearth Injection		X		X				495.2	0.04	0.0198
Transearth Coast to 400,000 ft.	Begin Transearth Coast	14935.5	248.94	Transearth Coast	X				X			178.5	1.14	0.2035
	First SXT Sighting After Injection	15005	250.08											

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Table C-I. Block II Command Module Power Profile for 14-Day Lunar Mission (cont)

		Minutes	Hours		1	2	3	4	5	6	7	8	9	10
Mission Phase	Mission Event	Time From Launch		G&N Activity	One AGC Operate 120.0 watts	Two AGC Operate 210.0 watts	AGC Standby 20.0 watts	IMU Operate 285.2 watts	IMU Standby 58.5 watts	Display & Controls 39.6 watts	Optics Operate 130.7 watts	Watts	Hours in Operation	Kilowatt Hours Consumed
Transearth Coast to 400,000 ft.	First SXT Sighting After Injection	15005	250.08											
				9 SXT Sightings 9.33% of the time	X				X	X	X	348.8	1.50	0.5232
				9 Computer Updates 0.93% of the time		X			X			268.5	0.15	0.0403
				Inactivity & Monitor 88.17% of the time			X		X			78.5	14.17	1.1123
	Complete IMU Alignment	15969	266.15	1 Alignment 1.55% of the time	X			X		X	X	575.5	0.25	0.1439
	Complete ΔV_1	15984	266.40	ΔV_1	X			X				405.2	0.25	0.1013
				Inactivity & Monitor 94.77% of the time			X		X			78.5	31.04	2.4366
				8 SXT Sightings 4.07% of the time	X				X	X	X	348.8	1.33	0.4639
				8 Computer Updates 0.40% of the time		X			X			268.5	0.13	0.0349
	Complete IMU Alignment	17949	299.15	1 Alignment 0.76% of the time	X			X		X	X	575.5	0.25	0.1439
	Complete ΔV_2	17964	299.40	ΔV_2	X			X				405.2	0.25	0.1013
				Inactivity & Monitor 93.82% of the time			X		X			78.5	31.60	2.4798
				10 SXT Sightings 4.94% of the time	X				X	X	X	348.8	1.66	0.5790
				10 Computer Updates 0.49% of the time		X			X			268.5	0.16	0.0429
	Complete IMU Alignment	19985	333.08	1 Alignment 0.74% of the time	X			X		X	X	575.5	0.25	0.1439
				Inactivity & Monitor 45.33% of the time			X	X				305.2	0.68	0.2075
				4 SXT Sightings 44.66% of the time	X			X		X	X	575.5	0.67	0.3856
				4 Computer Updates 4.66% of the time		X		X				495.2	0.07	0.0347
	Complete IMU Alignment	20075	334.58	1 Alignment 5.33% of the time	X			X		X	X	575.5	0.08	0.0460

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Table C-I. Block II Command Module Power Profile for 14-Day Lunar Mission (cont)

		Minutes	Hours		1	2	3	4	5	6	7	8	9	10
Mission Phase	Mission Event	Time From Launch		G&N Activity	One AGC Operate 120.0 watts	Two AGC Operate 210.0 watts	AGC Standby 20.0 watts	IMU Operate 285.2 watts	IMU Standby 58.5 watts	Display & Controls 39.6 watts	Optics Operate 130.7 watts	Watts	Hours in Operation	Kilowatt Hours Consumed
Transearth Coast to 400,000 ft.	Complete IMU Alignment	20075	334.83											
	Complete ΔV_3	20090	334.83	ΔV_3	X			X				405.2	0.25	0.1013
				Inactivity & Monitor 8.00% of the time			X	X				305.2	0.06	0.0183
				3 SXT Sightings 66.66% of the time	X			X		X	X	575.5	0.50	0.2878
				3 Computer Updates 6.66% of the time		X		X				495.2	0.05	0.0248
				Inactivity & Monitor 8.00% of the time	X			X				405.2	0.06	0.0243
				1 Alignment 10.66% of the time	X			X		X	X	575.5	0.08	0.0460
	Complete IMU Alignment	20135	335.58	Inactivity & Monitor	X			X				405.2	0.11	0.0445
	Begin Final AGC Update	20142	335.70	Computer Update		X		X				495.2	0.22	0.1089
Entry & Landing	Begin Entry	20155.5	335.94	Entry & Landing		X		X				495.2	0.47	0.2327
	Complete Landing	20183.5	336.41											
Post Landing	Post Landing	24503.5	408.39	Post Landing	—	—	—	—	—	—	—	0	0	0
											Total	—	336.41	55.636

(3) Second Computer Update: Since the Block II G&N System has two computers, a time of one (1) minute was available to update the second computer after each sextant sighting, landmark tracking, and star occultation. For similar considerations the second computer was turned on for additional fifteen (15) minutes prior to each major maneuver.

(4) ΔV Corrections: The major maneuvers are defined as ascent, translunar injection, lunar orbit injection, transearth injection, and entry. A time of fifteen (15) minutes was established for the time necessary to accomplish and confirm each of the three ΔV corrections during transearth and translunar operations.

(5) IMU Operation: The IMU is in operation from pre-launch until after the first midcourse correction.

Table C-I is a chronological time line and power profile for the Command Module established from the assumptions and definitions given above. It is designed for the 14-day mission and illustrates the time interval involved, as a function of mission phase, and AGE operating modes (defined to include all necessary G&N activities).

The column entitled mission phase contains the various phases of the nominal mission as defined by the NAA reference letter ICL 454-110-63-66 and corresponds to the associated time interval therein. The mission event column denotes a particular occurrence at each listed time. For convience, elapsed time is recorded in both hours and minutes. Associated with each activity (or group of recurrent activities) is a beginning and an ending time. The "X" in columns 1 through 7 marks the AGE equipment in operation during each activity. Column 8 is the power level for the operating mode of the G&N activity. Columns 9 and 10 are self-explanatory.

Table C-II is a summary of table C-I which compares AGE mode operating times (defined as G&N activity operating times) with AGE equipment operating times and lists the respective energy consumption in killowatt-hours.

Table C-II. Block II Command Module Power Profile Summary for 14-Day Lunar Orbit Mission

		ENERGY CONSUMPTION (Kilowatt Hours)							
		1	2	3	4	5	6	7	
Operating Mode	G&N ACTIVITY	One AGC Operate 120 watts 79.32 hours	Two AGC Operate 210 watts 3.98 hours	AGC Standby 20 watts 252.94 hours	IMU Operate 285.2 watts 76.19 hours	IMU Standby 58.5 watts 260.05 hours	D&C Operate 39.6 watts 19.27 hours	Optics Operate 130.7 watts 19.27 hours	TOTAL
A	Accomplish & confirm course corrections Inactivity & Monitor 405.2 watts 54.45 hrs.	6.534	----	----	15.529	----	----	----	22.063
B	Alignments Landmark Trackings SXT Sightings 575.5 watts 12.12 hrs.	1.454	----	----	3.456	----	0.480	1.584	6.974
C	Star Occultation Sightings 178.5 watts 5.6 hrs.	0.672	----	----	----	0.328	----	----	1.000
D	SXT Sightings (Midcourse) 348.8 watts 7.15 hrs.	0.858	----	----	----	0.418	0.283	0.934	2.493
E	Inactivity & Monitor 78.5 watts 245.70 hrs.	----	----	4.914	----	14.373	----	----	19.287
F	Inactivity & Monitor 305.2 watts 7.24 hrs.	----	----	0.145	2.065	----	----	----	2.210
G	Computer Updates Major Maneuvers 495.2 watts 2.38 hrs.	----	0.500	----	0.679	[illegible]	----	----	1.179
H	Computer Updates 268.5 watts 1.60 hrs.	----	0.336	----	----	0.094	----	----	0.430
	TOTAL 336.41 hours	9.518	0.836	5.059	21.729	15.213	0.763	2.518	55.636

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