C66-00126

[redacted]

DOWNGRADED AT 3 YEAR INTERVALS:
DECLASSIFIED AFTER 12 YEARS
DOD DIR 5200.10

CLASSIFICATION CHANGE
To UNCLASSIFIED
By authority of [illegible]
Changed by [illegible] Date [illegible]
Classified Document Master Control Station, NASA
Scientific and Technical Information Facility

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

APOLLO

GUIDANCE AND NAVIGATION

Approved: Milton B. Trageser Date: 3/15/65
MILTON B. TRAGESER, DIRECTOR
APOLLO GUIDANCE AND NAVIGATION PROGRAM

Approved: Roger B. Woodbury Date: 3/17/65
ROGER B. WOODBURY, DEPUTY DIRECTOR
INSTRUMENTATION LABORATORY

[redacted]

E-1142 (Rev. 30)
(UNCLASSIFIED TITLE)

SYSTEM STATUS REPORT

March 15, 1965

NOTICE — THIS DOCUMENT CONTAINS INFORMATION AFFECTING THE NATIONAL DEFENSE OF THE UNITED STATES WITHIN THE MEANING OF THE ESPIONAGE LAWS, TITLE 18, U.S.C., SECTIONS 793 AND 794. ITS TRANSMISSION OR THE REVELATION OF ITS CONTENTS IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW.

INSTRUMENTATION LABORATORY

CAMBRIDGE 39, MASSACHUSETTS

COPY # 42 OF 145 COPIES
THIS DOCUMENT CONTAINS 46 PAGES

[redacted]

ACKNOWLEDGMENT

This report was prepared under DSR Project 55-238 sponsored by the Manned Spacecraft Center of the National Aeronautics and Space Administration through Contract NAS 9-4065.

LIST OF EFFECTIVE PAGES

Page Numbers

Title Page through vii

1-1

2-1 through 2-9

3-1 through 3-7

4-1 through 4-5

5-1 through 5-8

Distribution List

CONTENTS

ILLUSTRATIONS

TABLES

ABSTRACT

The System Status Report is distributed monthly on the 15th. This month's revision of E-1142 (Rev. 30) 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

During the reporting period, MIT received notification by letter EG 2-65-64, dated February 18, 1965, from the MSC Project Office authorizing MIT to remove the MDV from the Block I 100 series and Block II G&N Systems.

It is the intent of MSC to complete the formulation of a program plan for the on-board Flight Data Book. The MSC Flight Crew Support Division will be responsible for the production of the Flight Data Book, and NAA/S&ID will be responsible for the storage and holding designs in the Command Module.

During the reporting period MIT completed a study requested by MSC on the design of full-eye-relief, full-magnification eyepieces for the SXT and SCT. If approved by MSC, these eyepieces would replace the two "normal" and two "eye relief" eyepieces reported here. The two eyepieces together would weigh about 2.8 lbs more than the four eyepieces they would replace. MIT has not been directed to incorporate these new eyepieces into the design at the time of this writing.

Included this month is the chronological weight history for the LEM G&N System (Appendix A).

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.

COMMAND MODULE

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. 29), February 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 (ZERO SERIES). At NASA Coordination Meeting No. 15A, MIT agreed to assign "not to exceed" design load weights for individual Block I G&N zero series subsystems. These weights were assigned by MIT in MIT letter AG-594-64, May 18, 1964, and are shown in column (d) of Table 2-I.

2-2 REPORTED 100 SERIES WEIGHT CHANGES

2-2.1 CDU ASSY (+0.1 lb). The increase of 0.1 lb is due to the weighing of the mechanical CDU hardware.

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 2/65 (b)	(c-b)	100 Series Status 3/65 (c)	0 Series Design Load Wt. 5/64 (d)
G&N SYSTEMS						
CDU Assy			14.0 (E)	+0.1	14.1 (M)	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			80.0 (E)	+7.0	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
MDV (includes 1 film)			9.1 (E)	-9.1	0.0	
D&C/AGC			21.9 (C)	+1.1	23.0 (M)	
Horizon Photo. Elect.			2.2 (C)	0.0	2.2 (C)	0.0
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 2/65 (b)	(c-b)	100 Series Status 3/65 (c)	0 Series Design Load Wt. 5/64 (d)
MAIN PANEL AREA						
D&C/AGC			21.9 (C)	+1.1	23.0 (M)	26.0
LOOSE STORED ITEMS						
Eye Relief Eyepieces			1.5 (E)	0.0	1.5 (E)	3.0
Film Cartridges (4)			2.5 (C)	-2.5 (C)	0.0	5.0
Optics Cover			1.6 (C)	0.0	1.6 (C)	2.5
TOTAL	430.0*	-11.2	418.8	-2.3	416.5	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 MIT letter AG-594-64 (May 18, 1964). See paragraph 2-1.3. Applies to zero series only.

2-2.2 MDV (-9.1 lbs). The MDV has been removed from the G&N System. The intent is to replace the MDV with an on-board Flight Data Book (for further explanation, see paragraph 1-1).

2-2.3 FILM CARTRIDGES (-2.5 lbs). Since the MDV has been removed from system use, the film cartridges are no longer required.

2-2.4 AGC (+7.0 lbs). The increase is due to the actual weighing of System 120. The weight includes the computer, miscellaneous hardware, four rope modules and two rope jumpers.

2-2.5 D&C/AGC LEB (+1.1 lbs). The increase is due to the actual weighing of System 120.

2-2.6 D&C/AGC MP (+1.1 lbs). See paragraph 2-2.5.

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 Y -0.3 Z 37.3	Ixx 681,030 Iyy 1,939,064 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

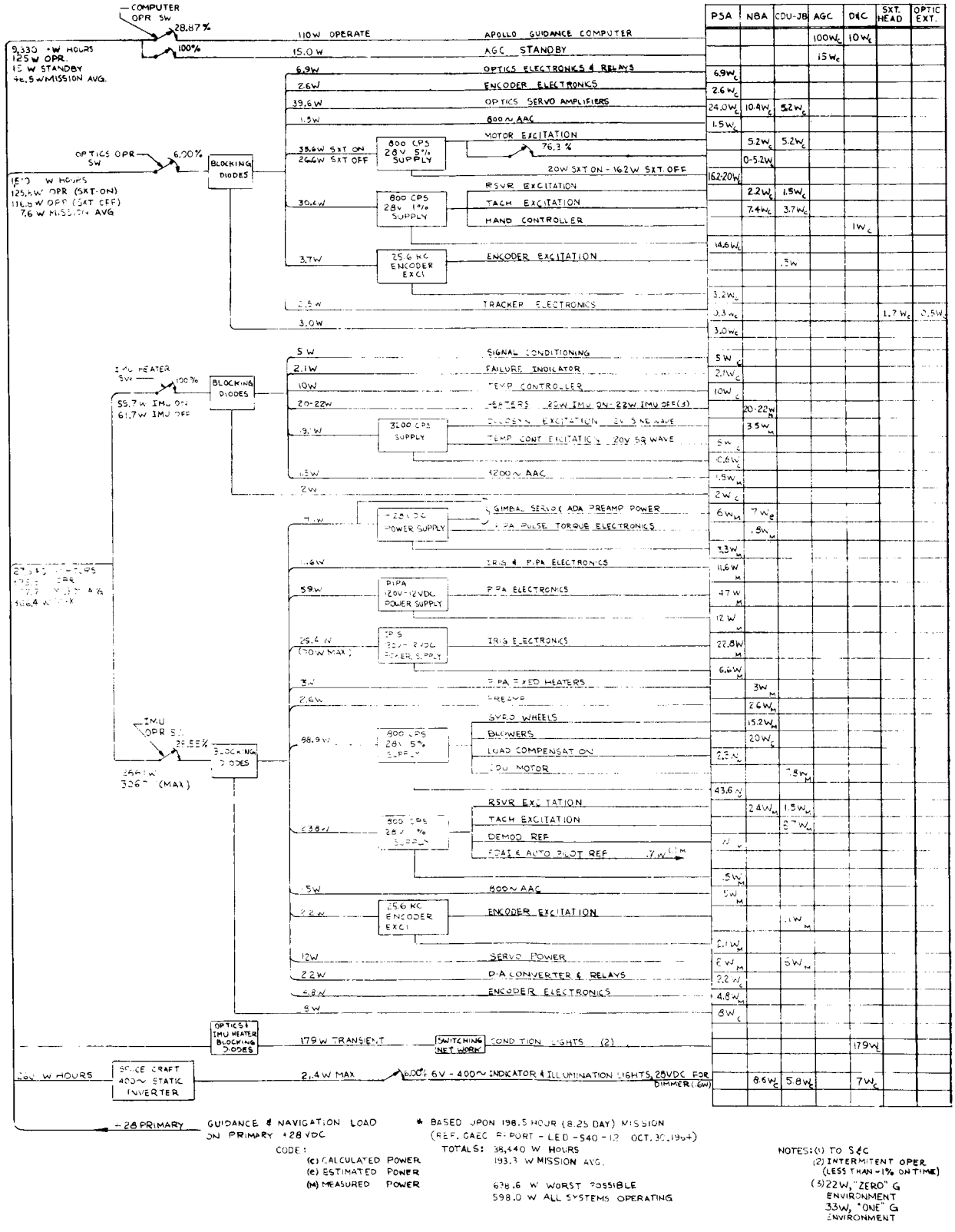


Figure 2-1. Electrical Load on Primary +28 VDC Power Supply for Block I (100 Series) Systems

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 (3/15/65)

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 INTRODUCTION

Because of the change in the basic packaging concept of the G&N System from Block I to Block II, the G&N Harness and PSA End Connector Assembly have been replaced by a PSA header and a group of nine individual interconnect cables referred to as the Interconnect Cable Harness Assembly.

These cables will electrically tie together the assemblies which make up the G&N System and will also interface with the spacecraft.

3-2 RELIABILITY

A new Design Reference Mission has been developed by the Apollo Mission Planning Task Force (GAEC Report LED-540-12, October 30, 1964). The reliability values are now in the process of being recalculated to reflect these new mission requirements and will be reported in next month's report. Table 3-I shows reliability figures in effect before implementation of the new requirements.

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.

3-3 WEIGHTS FOR THE BLOCK II COMMAND MODULE

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

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

Item	Design Weight (a)	(b-a)	Status 2/65 (b)	(c-b)	Status 3/65 (c)	Design Load Wt. 5/64 (d)
G&N SYSTEMS						
CDU Assy			33.0(E)	0.0	33.0(E)	
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						
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*			47.7(E)	- 6.2	41.5(E)	
PIPA Electronics Assy			0.0	+ 7.9	7.9(E)	
G&N Interconnection Harness Assy			31.0(E)	-31.0	0.0	
G&N to S/C Interface Assy			8.5(E)	- 8.5	0.0	
Interconnect Harness Assy			0.0	+30.0	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						
D&C Electronics			0.0	0.0	0.0	
Control Electronics			0.0	0.0	0.0	
G&N Ind Cont Panel			12.1(E)	0.0	12.1(E)	
MDV (includes 1 film cartridge)			9.1(E)	- 9.1	0.0	

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

	Design Weight (a)	(b-a)	Status 2/65 (b)	(c-b)	Status 3/65 (c)	Design Load Wt. 5/64 (d)
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)	
LOOSE STORED ITEMS						
Eye Relief Eyepieces			1.5 (E)	0.0	1.5 (E)	
Film Cartridges (4)			2.5 (E)	-2.5 (E)	0.0	
Optics Cover			1.6 (C)	0.0	1.6 (C)	
TOTAL	400.0†	-26.2	373.8	-19.4	354.4	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 does not include loose stored items.

3-4 REPORTED BLOCK II WEIGHT CHANGES

3-4.1 PSA (-6.2 lbs). As reported in last month's issue, the Block II PSA has been divided into the PSA (41.5 lbs) and PIPA Electronics Assembly (7.9 lbs). The combined weight of the two assemblies is greater than the original PSA weight because of the requirement to environmentally seal these two packages and to electrically tie them to the total G&N System.

3-4.2 PIPA ELECTRONICS ASSY (+7.9 lbs). See paragraph 3-4.1.

3-4.3 G&N INTERCONNECTION HARNESS ASSY (-31.0 lbs) AND G&N TO S/C INTERFACE ASSY (-8.5 lbs). The latest installation does not identify the G&N Interconnection Assy and G&N to S/C Interface Assy as separate hardware but shows them combined as one piece now referred to as the Interconnect Harness Assy (+30.0 lbs). Its weight was derived from weighing the mockup which was built for NAA mockup review meeting held at NAA on February 23, 1965.

3-4.4 INTERCONNECT HARNESS ASSY (+30.0 lbs). See paragraph 3-4.3.

3-4.5 MDV (-9.1 lbs). See paragraph 2-2.2.

3-4.6 FILM CARTRIDGES (-2.5 lbs). See paragraph 2-2.3.

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 a 8.25-day lunar orbit mission as defined by the Apollo Mission Planning Task Force (AMPTF) for power profile computation and is based on 28 VDC input at the connectors. These values are average values (Ref: GAEC Report LED-540-12, October 30, 1964). Since the 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-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 3-IV 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 activites (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.

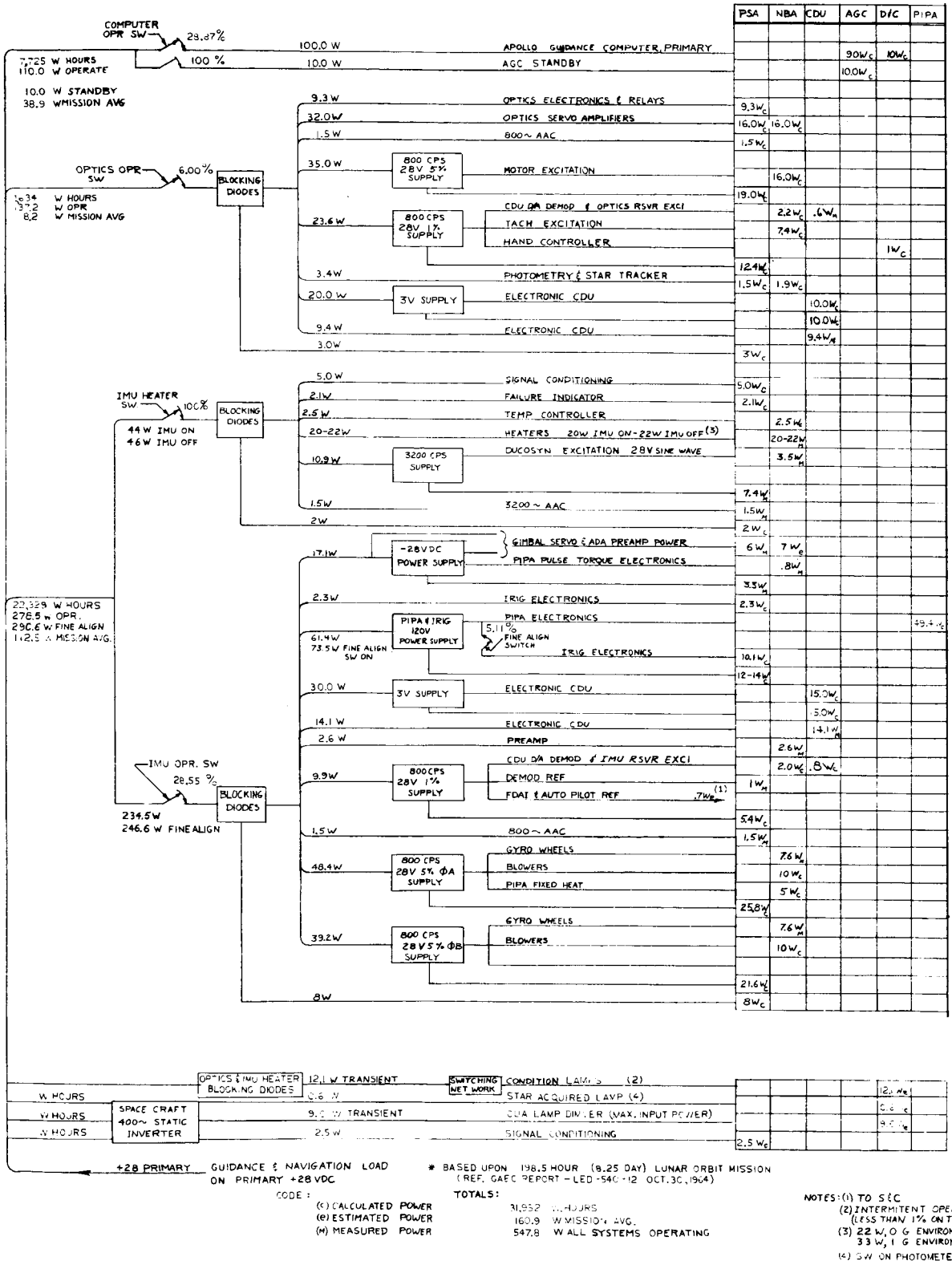


Figure 3-1. Electrical Load on Primary +28 VDC Power Supply

Table 3-III. 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-IV. 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 INTRODUCTION

The Landing Point Designator (LPD) was the subject of NASA LEM Coordination Meeting L10A held on February 16, 1965, at MSC. Responsibility for the design and procurement of this device was assigned to GAEC. When MIT receives official direction to remove the LPD from MIT-supplied hardware, a corresponding weight reduction will be shown in this report.

MSC letter EG-2-65-64 to MIT, dated February 18, 1965, on the removal of the MDV from the Command Module stated that GAEC would have responsibility for the Flight Data Book in the LEM similar to that of NAA for the Command Module. It was not clear whether the book reported here under the LEM G&N weight would be removed by action of this letter. If MIT is so directed, the book weight will be removed from this report.

As a result of preliminary ICD negotiation with GAEC, the Signal Conditioner Assembly will be located on top of the LEM PSA within a six-inch-high "envelope." As the Signal Conditioner Assembly becomes more fully defined, the weight will be reported.

4-2 RELIABILITY

The LEM G&N reliability values are now in the process of being recalculated to reflect the new Design Reference Mission requirements and will be reported in next month's report (for further explanation see paragraph 3-2). Table 4-I shows the reliability figures in effect before implementation of the new requirements.

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

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

	Control Weight (a)	(b-a)	Status 2/65 (b)	(c-b)	Status 3/65 (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)	115.0	+12.3	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.

4-3 WEIGHTS FOR LEM

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

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

4-4 REPORTED LEM WEIGHT CHANGES

No weight changes were reported this month.

4-5 POWER REQUIREMENTS

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

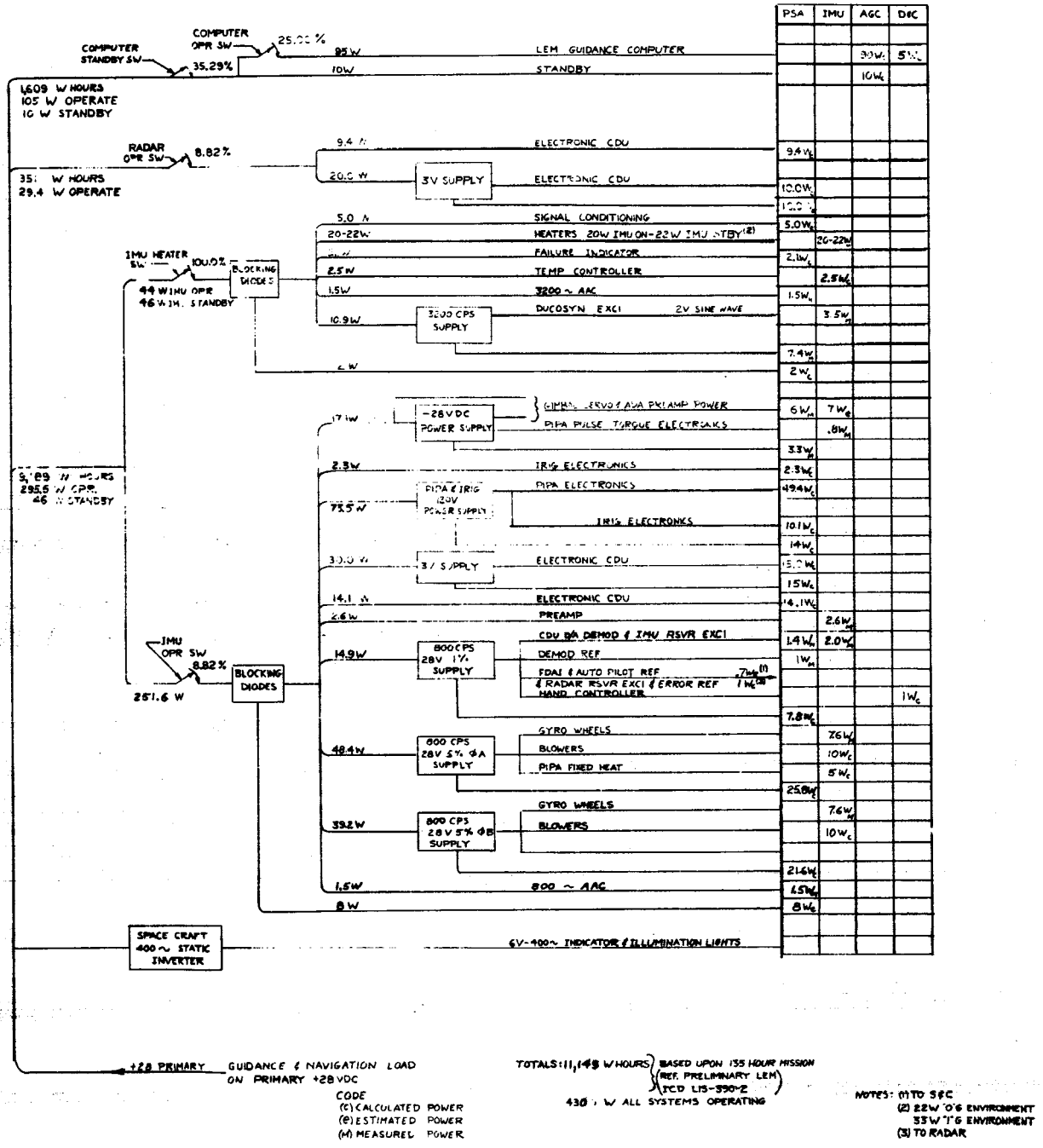


Figure 4-1. Electrical Load on Primary +28 VDC Power Supply

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.

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 tachometer, resolver synchros, and encoder with mounting frame work. Does not include associated electronics which are located in the PSA.

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

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

Cold Plates

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

Control Electronics Assembly

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

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

LEM Not required.

Inertial Measurement Unit (IMU)

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

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

IMU Control Panel

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

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

LEM Does not exist in LEM.

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 Functionally similar to Block I but will be lighter and 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 reorientation of the NVB so that the IMU axes will be parallel to the Command Module axes.

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

Optical Eyepieces

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

LEM Included as part of the AOT.

Optical Subsystem

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

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

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 Electronics 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.

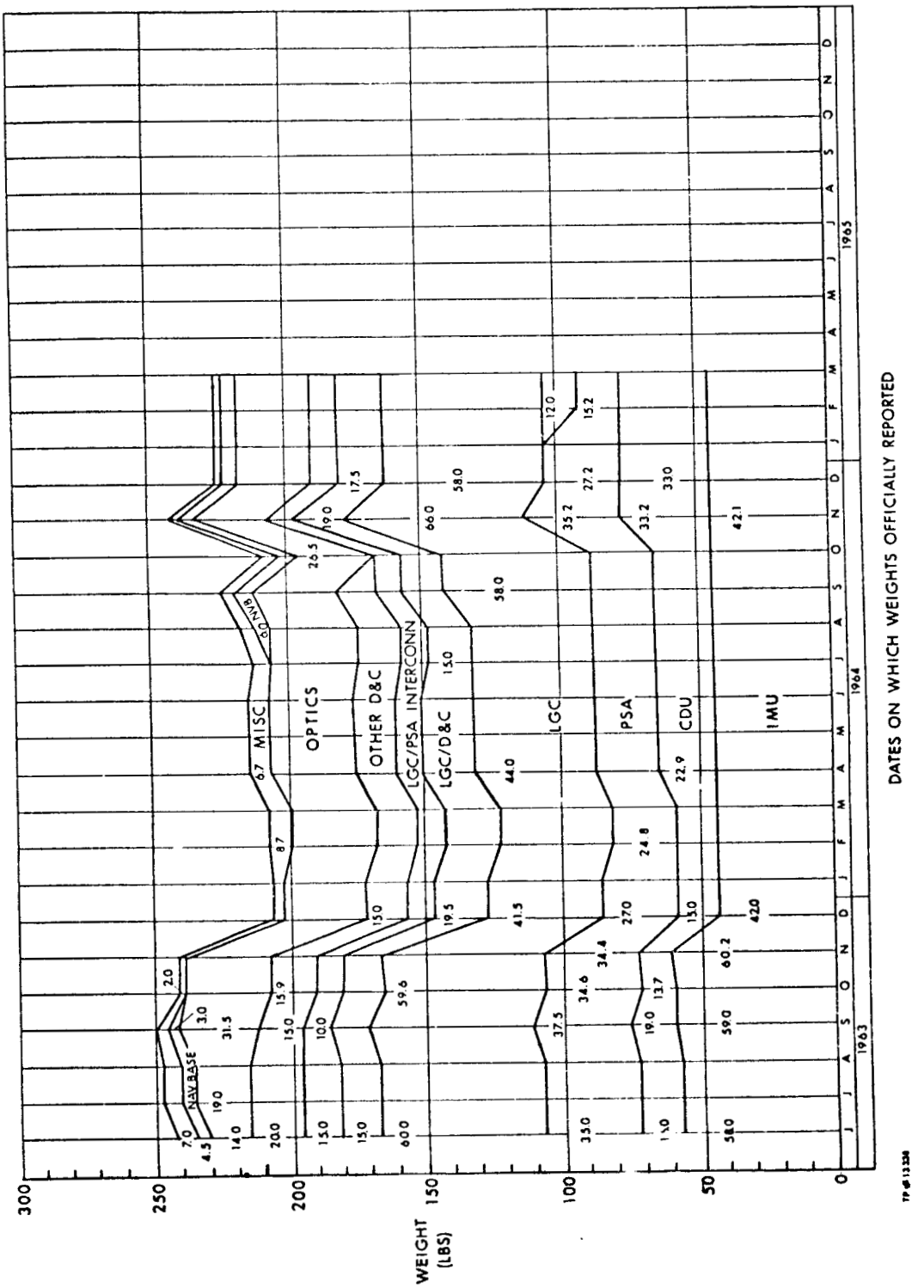
CM BLOCK II These modules are located in the same volume now occupied by the Block I CDU's.

LEM Same as for Block I.

LUNAR EXCURSION MODULE

Appendix A

CHRONOLOGICAL WEIGHT STATUS OF LEM G&N EQUIPMENT



DISTRIBUTION LIST
E-1142, Rev.30

Apollo Limited Internal

Alonso, R.	Hanley, D.	Miller, J.
Apollo Library (5)	Hickey, E.	MIT/IL Library (W-1) (8)
Battin, R.	Hoag, D.	Nevins, J.
Bean, W.	Houston, F.	Nugent, J.
Bowditch, P.	Hursh, J.	Olsson, E.A.
Boyce, A.	Koso, A.	Schwarm, E.
Dahlen, J.	Kramer, M.	Sciegienny, J.
Dunipace, K. (AMR)	Kupfer, W.	Sears, N.
Duggan, E.	Ladd, D.	Stameris, W.
Feldman, J.B.	Larson, L.	Stone, J.
Flanders, J.	Lawrence, J. (GAEC)	Trageser, M.
Felix, S. (S&ID)	Lawton, R.	Wilk, L. (2)
Hall, E.C.	Marland, L.	Woodbury, R.
Halzel, I.	Mayo, G.	

External

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

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

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

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

NAA:

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

MSC:

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

WESCo

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

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

ACSP RASPO:

National Aeronautics and Space Admin. (1)
Resident Apollo Spacecraft Program Officer
Dept. 32-31
AC Spark Plug Div. of General Motors
Milwaukee, Wisconsin
Attn: Mr. W. Swingle

Mr. H. Peterson
Bureau of Naval Weapons
c/o Raytheon Company
Foundry Avenue
Waltham, Massachusetts

Mr. S. Schwartz
Queens Material Quality Section
c/o Kollsman Instrument Corp.
Building A
80-08 5 Ave
Elmhurst, New York 11373

Mr. H. Anschuetz
USAF Contract Mgt. District
AC Spark Plug Div. of General Motors
Milwaukee, Wisconsin 53201