APOLLO

GUIDANCE AND NAVIGATION

Approved: Milton B. Trageser Date: 9/11/64
MILTON B. TRAGESER, DIRECTOR
APOLLO GUIDANCE AND NAVIGATION PROGRAM

Approved: Roger B. Woodbury Date: 9/18/64
ROGER B. WOODBURY, DEPUTY DIRECTOR
INSTRUMENTATION LABORATORY

E-1142 (Rev. 24)

(UNCLASSIFIED TITLE)

SYSTEM STATUS REPORT

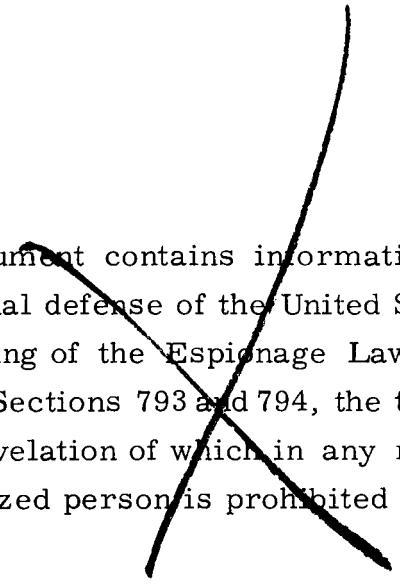
September 15, 1964

INSTRUMENTATION LABORATORY

CAMBRIDGE 39, MASSACHUSETTS

ACKNOWLEDGMENT

This report was prepared under DSR Project 55-191, sponsored by the Manned Spacecraft Center of the National Aeronautics and Space Administration through Contract NAS 9-153.



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, the transmission or the revelation of which in any manner to an unauthorized person is prohibited by law.

LIST OF EFFECTIVE PAGES

Page Numbers

Title Page through vi

1-1

2-1 through 2-8

3-1 through 3-5

4-1 through 4-3

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. 24) contains, in general, the following information for the Block I and Block II Command Module and Lunar Excursion Module equipment configurations: weights, centers of gravity, moments of inertia, power requirements, status of computer programs, and reliability values.

Section 1

INTRODUCTION

1-1 INTRODUCTION

The definition of what constitutes Block I, Block II, and LEM hardware is contained in the Glossary, section 5 of this report.

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

(1) Command Module, Block I
100 Series: Weights and power requirements.
Zero Series: Total weight, center of gravity and moment of inertia values.

(2) Command Module, Block II
Post-June 1964 configuration: Weights.
Pre-June 1964 configuration: Status of computer programs and reliability values.

(3) Lunar Excursion Module.
Pre-September 1964 configuration: Weights and reliability values.

The significance of the dates mentioned above is explained in the respective sections of this report.

1-2 ACCURACY

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

Section 2

BLOCK I COMMAND MODULE DATA

2-1 WEIGHTS

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

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

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

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

2-1.1 WEIGHTS STATUS REPORTING. Table 2-I also offers a comparison of present 100 series component weight values with those listed in System Status Report, E-1142 (Rev. 23). August 15, 1964. All weight changes are explained in paragraph 2-2.

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

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

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

Item	0 Series Status 2/64 (a)	(b-a)	100 Series Status 8/64 (b)	(c-b)	100 Series Status 9/64 (c)	Design Load Wt. 5/64 (d)**
G&N SYSTEMS						
CDU Assy	14.5 (M)	-0.9	13.6 (C)	0.0	13.6 (C)	18.0
Optical Subsystem						
SXT	14.6 (C)	+4.1	18.7 (E)	0.0	18.7 (E)	
SCT	13.8 (C)	+0.5	14.3 (E)	0.0	14.3 (E)	
Optical Base & Gearing	16.7 (E)	+0.3	17.0 (E)	0.0	17.0 (E)	
Optical Eyepieces						
SXT	1.3 (E)	+0.3	1.6 (C)	0.0	1.6 (C)	100.0
SCT	2.3 (E)	+0.3	2.6 (C)	0.0	2.6 (C)	
NVB & Resilient Mounts	25.0 (E)	+0.7	25.7 (C)	0.0	25.7 (C)	
Bellows Assy	13.5 (M)	-0.8	12.7 (C)	0.0	12.7 (C)	
IMU	60.2 (M)	+0.3	60.5 (C)	0.0	60.5 (C)	65.0
Coolant Hoses (two)	1.0 (E)	-0.2	0.8 (E)	0.0	0.8 (E)	
Power Servo Assy	59.4 (C)	-0.5	58.9 (C)	0.0	58.9 (C)	75.0
G&N Interconnection Assy	35.2 (E)	-5.2	30.0 (C)	0.0	30.0 (C)	45.0
G&N to S/C Interface Assy	8.0 (E)	+5.0	83.0 (E)	0.0	83.0 (E)	100.0
AGC (no spares)	70.0 (E)					
Optical Shroud	3.5 (M)	-0.4	3.1 (C)	0.0	3.1 (C)	4.5
LOWER EQUIPMENT BAY						
D&C						
D&C Electronics	2.9 (M)	0.0	2.9 (C)	0.0	2.9 (C)	
Control Electronics	2.9 (E)	-0.9	2.0 (C)	0.0	2.0 (C)	
G&N Ind Cont Panel	9.5 (M)	+0.4	9.9 (C)	0.0	9.9 (C)	70.0
IMU Control Panel	2.4 (M)	+0.2	2.6 (C)	0.0	2.6 (C)	
MDV (includes 1 film)	7.7 (C)	+1.9	9.6 (C)	0.0	9.6 (C)	
D&C/AGC	20.6 (M)	+0.8	21.4 (C)	0.0	21.4 (C)	
Horiz. Photo. Elect.	0.0	+3.3	3.3 (E)	0.0	3.3 (E)	0.0
Signal Conditioner Assy	0.0	+4.6	4.6 (E)	0.0	4.6 (E)	8.0

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

Item	0 Series Status 2/64 (a)	(b-a)	100 Series Status 8/64 (b)	(c-b)	100 Series Status 9/64 (c)	Design Load Wt. 5/64 (d)**
MAIN PANEL AREA						
D&C/AGC	20.5 (M)	+0.9	21.4 (C)	0.0	21.4	26.0
LOOSE STORED ITEMS						
Eye Relief Eyepieces	1.5 (E)	0.0	1.5 (E)	0.0	1.5 (E)	3.0
Film Cartridges (4)	2.4 (E)	+0.1	2.5 (C)	0.0	2.5 (C)	5.0
Horizon Photometer	3.6 (E)	-3.6	0.0	0.0	0.0	0.0
Optics Cover	1.7 (M)	-0.1	1.6 (C)	0.0	1.6 (C)	2.5
TOTAL	415.0*	+10.8	425.8	0.0	425.8	522.0

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

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

2-2 REPORTED 100 SERIES WEIGHT CHANGES

No weight changes were reported this month.

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

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

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

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

Weight (lb)	Center of Gravity* (in)	Moments of Inertia* ($lb\text{-}in^2$)
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 14-day lunar mission as defined by S&ID for power profile computation (Ref: S&ID letter 63 MA 7332).

This new power chart (figure 2-1) represents a total energy consumption increase of approximately 1900 watt hours over the power chart for the zero series systems shown in last month's report. The following power changes are reported:

(1) AGC (+3,366 watt hours). The AGC standby condition increased from 10 to 20 watts as a result of the Block I (100 series) redesign which prevented the required module modifications to achieve the original 10-watt estimate.

COMMAND MODULE

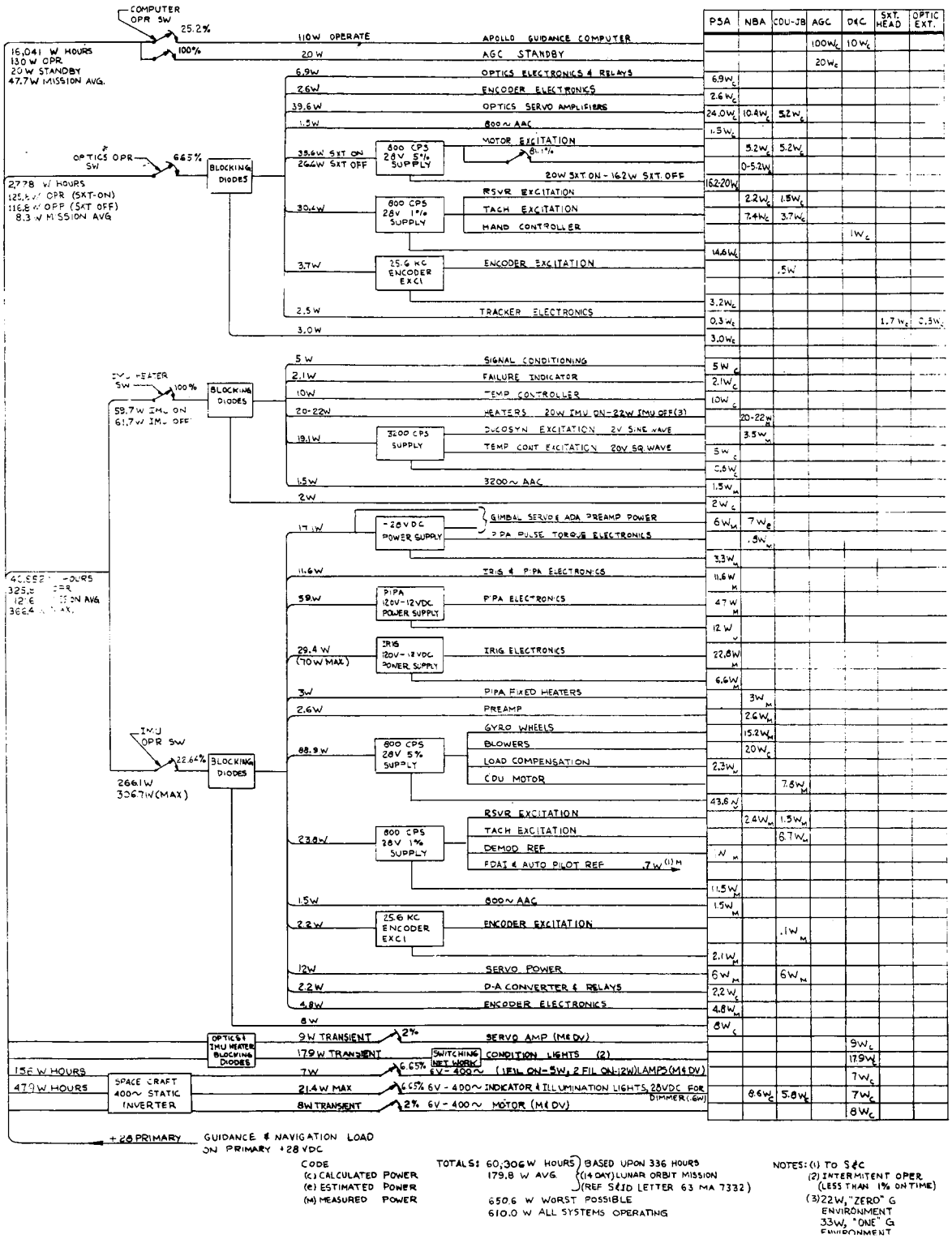


Figure 2-1. Electrical Load on Primary +28 VDC Power Supply

(2) Optics (+329 watt hours).

(a) Optics electronics and relays. The following power changes were noted:

R.D.A.	0.7 to 1.5 watt
Cosecant Ampl.	0.35 to 0.2 watt
Mod. & Loop Comp.	0 to 0.25 watt
25% Offset	0.10 to 0.85 watt

(b) Optics servo amplifiers (+10.6 watts). Larger amplifiers are required in the 100 series systems.

(c) Tracker electronics (+2.5 watts). This item does not exist in zero series systems.

(d) SXT eyepiece heater. Not estimated as yet.

(3) IMU (-1,686 watt hours). Five watts is a better power estimate than 10 watts for signal conditioning.

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 14-day mission submitted by S&ID in S&ID letter 63 MA 7332. The column also indicates the power requirement and operating time for each specific activity. The top row indicates the power requirement and operating time of each G&N power consuming equipment. The table sums up the energy consumptions for each G&N activity and each G&N power consuming equipment.

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	Optics External	D&C and S&C	Electrical Load
		IMU	OBA		IMU	OBA					
A	IMU & AGC Operate (1,5)	74.5	0.0	22.1	228.5	0.0	120.0	445.1	0.0	10.7	455.8
B	IMU Alignment (1,3,5,7)	74.5	40.7	44.0	228.5	76.1	120.0	583.8	0.5	25.7	610.0
C	Low-Orbit Navigation (1,4,5,7)	74.5	35.5	44.0	228.5	72.3	120.0	574.8	0.5	25.7	601.0
D	Standby & Computing (1,6)	25.5	0.0	0.0	36.2	0.0	120.0	181.7	0.0	10.0	191.7
E	Midcourse Navigation (1,3,6,7)	25.5	40.7	21.9	36.2	76.1	120.0	320.4	0.5	25.0	345.9
F	IMU & AGC Standby (2,6)	25.5	0.0	0.0	36.2	0.0	20.0	81.7	0.0	0.0	81.7
G	IMU Operate and AGC Standby (2,5)	74.5	0.0	22.1	228.5	0.0	20.0	345.1	0.0	0.7	345.8

1.	AGC	130.0 watts
2.	AGC Standby	20.0 watts
3.	Optics, SXT on	125.8 watts
4.	Optics, SXT off	116.8 watts
5.	IMU Operate	325.8 watts
6.	IMU Standby	61.7 watts
7.	Display and Control	28.4 watts

Table 2-IV. Block I (100 Series) Command Module Profile for 14-Day Lunar Orbit Mission

MODE	G&N Activity	Energy Consumption (kwh)							
		(1) AGC Operate 130 watts 84.67 hrs	(2) AGC Standby 20.0 watts 251.74 hrs	(3) Optics SXT on 125.8 watts 18.53 hrs	(4) Optics SXT off 116.8 watts 3.83 hrs	(5) IMU Operate 325.8 watts 76.09 hrs	(6) IMU Standby 61.7 watts 260.32 hrs	(7) Display & Controls 28.4 watts 22.36 hrs	Total
A	IMU & AGC Operate 455.8 watts, 56.71 hrs	7.372	--	--	--	18.476	--	--	25.848
B	IMU Alignment 610.0 watts, 8.20 hrs	1.066	--	1.032	--	2.672	--	0.233	5.003
C	Low-Orbit Navigation 601.0 watts, 3.83 hrs	0.498	--	--	0.447	1.248	--	0.109	2.302
D	Standby & Computing 191.7 watts, 5.60 hrs	0.728	--	--	--	--	0.346	--	1.074
E	Midcourse Navigation 345.9 watts, 10.33 hrs	1.343	--	1.299	--	--	0.637	0.293	3.572
F	IMU & AGC Standby 81.7 watts, 244.39 hrs	--	4.887	--	--	--	15.079	--	19.966
G	IMU Operate & AGC Standby 345.8 watts, 7.35 hrs	--	0.147	--	--	2.394	--	--	2.541
	TOTAL	11.007	5.034	2.331	0.447	24.790	16.062	0.635	60.306

Section 3

BLOCK II COMMAND MODULE DATA

3-1 INTRODUCTION

On June 4, 1964, MSC reoriented the Block II G&N System to include spacecraft powered and free-fall stabilization and control functions (Ref: minutes of meeting, S&ID, MIT/IL, and MSC Implementation Meeting No. 1, June 4, 1964, MSC, Houston, Texas). The weight estimates included in this section are based on the above configuration, while the reliability and status of AGC program values are based on the pre-June 1964 configuration.

3-2 RELIABILITY

The reliability numbers shown in Table 3-I do not assume the use of in-flight spares or repair but do include the use of a redundant computer. Estimated Command Module G&N reliability is based on the 138-hour mission as defined in the Lunar Landing Mission Design Plan. These numbers are in the process of being recalculated for realignment of the interface configuration since Block II will now use only one computer.

Table 3-I. Reliability (as of 9/15/64)

Subsystem	Operation Time (hrs) Full Power	Probability of Mission Success
IMU	31	0.99576
AGC (2)	19*	0.99996
DSKY	19	0.99995
PSA	31*	0.99421
CDU (5)	31	0.99426
Optics	18	0.99804
Total G&N System		0.98229

*Certain assemblies function continuously.

3-3 WEIGHTS

Table 3-II presents the weights of the Block II Command Module post-June 1964 concept defined in paragraph 3-1. Refer to paragraph 2-1 for a general explanation of weight reporting.

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

Item	Pre-June* Status 2/64 (a)	(b-a)	Pre-June* Status 8/64 (b)	(c-b)	Post-June* Status 9/64 (c)	Design Load Wt. 5/64 (d)
G&N SYSTEMS						
CDU Assy	15.0 (E)	+7.9	22.9 (E)	0.0	22.9 (E)	
Optical Subsystem						
SXT	18.2 (C)	+0.5	18.7 (E)	0.0	18.7 (E)	
SCT	13.8 (C)	+0.5	14.3 (E)	0.0	14.3 (E)	
Optical Base & Gearing	16.7 (E)	+0.3	17.0 (E)	0.0	17.0 (E)	
Optical Eyepieces						
SXT	1.3 (E)	+0.3	1.6 (E)	0.0	1.6 (E)	
SCT	2.3 (E)	+0.3	2.6 (E)	0.0	2.6 (E)	
NVB & Resilient Mounts	22.0 (E)	-4.0	18.0 (E)	+5.0	23.0 (E)	
Bellows Assy	13.5 (C)	-0.8	12.7 (C)	0.0	12.7 (C)	
IMU	42.0 (E)	0.0	42.0 (E)	+0.1	42.1 (E)	
Coolant Hoses (two)	1.0 (E)	-0.3	0.7 (E)	+0.1	0.8 (E)	
Power Servo Assy	41.6 (E)	0.0	41.6 (E)	0.0	41.6 (E)	
G&N Interconnection Assy	35.2 (E)	-5.2	30.0 (E)	0.0	30.0 (E)	
G&N to S/C Interface Assy	8.0 (E)	0.0	8.0 (E)	0.0	8.0 (E)	
AGC	84.0 (E)	+4.0	88.0 (E)	-30.0	58.0 (E)	
Optical Shroud	3.5 (C)	-0.4	3.1 (E)	0.0	3.1 (E)	
LOWER EQUIPMENT BAY						
D&C						
D&C Electronics	1.5 (E)	0.0	1.5 (E)	0.0	1.5 (E)	
Control Electronics	2.9 (E)	-0.9	2.0 (E)	0.0	2.0 (E)	
G&N Ind Cont Panel	11.1 (E)	0.0	11.1 (E)	0.0	11.1 (E)	
MDV (includes 2 films)	8.3 (E)	+1.3	9.6 (E)	0.0	9.6 (E)	
D&C/AGC	20.6 (E)	-5.6	15.0 (E)	0.0	15.0 (E)	

(cont)

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

Item	Pre-June* Status 2/64 (a)	(b-a)	Pre-June* Status 8/64 (b)	(c-b)	Post-June* Status 9/64 (c)	Design Load Wt. 5/64 (d)
MAIN PANEL AREA						
D&C/AGC	20.5 (E)	-5.5	15.0 (E)	0.0	15.0 (E)	
LOOSE STORED ITEMS						
Eye Relief Eyepieces	1.5 (E)	0.0	1.5 (E)	0.0	1.5 (E)	
Film Cartridges (3)	1.8 (E)	+0.1	1.9 (E)	0.0	1.9 (E)	
AGC Cover	8.5 (E)	-4.0	4.5 (E)	-4.5	0.0	
PSA Cover	3.5 (E)	0.0	3.5 (E)	0.0	3.5 (E)	
Optics Cover	1.7 (E)	-0.1	1.6 (C)	0.0	1.6 (C)	
TOTAL	400.0** Control Weight	-11.6	388.4	-29.3	359.1	492.6***

*See paragraph 3-1.

**Control Weight specified in letter (PG-64-113, March 6, 1964) from Mr. D. Gilbert, ASPO, to Mr. M. Trageser, MIT/IL. See paragraph 2-1.2.

***Design Load Weight taken from S&ID letter 63 MA 2032, February 11, 1964. Does not include loose stored items.

3-4 REPORTED WEIGHT CHANGES

The weight changes shown in column (c - b) of Table 3-II are explained below.

3-4.1 NVB & RESILIENT MOUNTS (+5.0 lbs). A NVB transition piece must be added in order to reorient the NVB so that the axes of the IMU will be parallel to the X, Y, Z axes of the Command Module. This reorientation was directed by MSC during the guidance and control implementation meetings.

3-4.2 COOLANT HOSES (+0.1 lbs). The aluminum flex hoses have been changed to steel for strength and manufacturability.

3-4.3 AGC (-30.0 lbs). At Guidance and Control Implementation Meeting No. 1, June 4, 1964, NASA directed that there will be only one computer (instead of two) in the Block II systems configuration. See Glossary, section 5, for a description. The Block II computer now listed incorporates much more interface capability, more memory, and new logic to meet the control functions which were summarized August 17 as a result of the Block II G&C implementation meetings.

3-4.4 AGC COVER (-4.5 lbs). The cover weight is included in the AGC weight.

3-5 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 (Pre-June 1964 configuration**)

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

*Programs in stage (5) whose low and high estimates are not identical reflect an anticipated increase in computational facility.
**See paragraph 3-1.

Section 4

LUNAR EXCURSION MODULE DATA

4-1 INTRODUCTION

A series of four meetings starting September 1, 1964 have been scheduled by MSC to redefine the LEM guidance and control functions. Status reporting on the LEM hardware will be directly influenced by the activity of this new program definition phase. For this reason only best-guess estimates will be made for weight. Other parameters, such as power, will not be included in this report until the configuration is better defined. Estimated reliabilities, however, are given.

4-2 RELIABILITY

The numbers in Table 4-I do not assume the use of in-flight spares or repair. Estimated reliabilities are based on MIT/IL's Guidance Monitor System Note No. 3, dated January 23, 1964.

Table 4-I. Reliability (as of 9/15/64)

Subsystem	Operating Time (hrs)	Probability of Mission success
IMU	6.25	0.99914
AGC	6.25	0.99768
PSA	6.25	0.99928
CDU (5)	6.25	0.99897
OMU	0.75	0.99997
Total G&N System		0.99505

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.

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

Item	Status 2/64 (a)	(b-a)	Status 7/64 (b)	(c-b)	Status 8/64 (c)	Design Load Wt. 7/64 (d)
CDU's	15.0 (E)	+7.9	22.9 (E)	0.0	22.9 (E)	**
Telescope and All Eyepieces	24.5 (E)	0.0	24.5 (E)	0.0	24.5 (E)	
Eye Register for Reticule	2.0 (E)	0.0	2.0 (E)	0.0	2.0 (E)	
Two-Digit Readout for Reticule	5.0 (E)	0.0	5.0 (E)	0.0	5.0 (E)	
IMU	42.0 (E)	0.0	42.0 (E)	0.0	42.0 (E)	
AGC/PSA Interconnection Assy	10.0 (E)	0.0	10.0 (E)	0.0	10.0 (E)	
AGC Display and Controls	19.5 (E)	-4.5	15.0 (E)	0.0	15.0 (E)	
Other Displays and Controls	15.0 (E)	0.0	15.0 (E)	0.0	15.0 (E)	
Book of Procedures, etc.	2.0 (E)	0.0	2.0 (E)	0.0	2.0 (E)	
AGC	41.5 (E)	-2.5	44.0 (E)	+14.0	58.0 (E)	
AGC Cover	4.3 (E)	-2.0	2.3 (E)	-2.3	0.0	
PSA	24.8 (E)	0.0	24.8 (E)	0.0	24.8 (E)	
PSA Cover	2.4 (E)	0.0	2.4 (E)	0.0	2.4 (E)	
NVB	0.0	+6.0	6.0 (E)	0.0	6.0 (E)	
Total	210.0* Control Weight	+7.9	217.9	+11.7	229.6	
Bare Guidance System (IMU, PSA, and AGC)	108.3	+2.5	110.8	+14.0	124.8	

*Control Weight specified in Letter PG-64-113 (March 6, 1964) from Mr. D. Gilbert, ASPO, to Mr. M. Trageser, MIT/IL. See section 2-1.2.

**No design load weight has been assigned.

4-4 REPORTED WEIGHT CHANGES

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

4-4.1 AGC (+14.0 lbs). The LEM computer will be identical to the Block II computer. See paragraph 3-3.4.

4-4.2 AGC COVER (-2.3 lbs). The AGC cover weight is included in the new AGC weight estimate.

Section 5

GLOSSARY AND SYSTEM DEFINITION

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

Apollo Guidance Computer (AGC)

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

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

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

AGC Cover

CM BLOCK I, BLOCK II, AND LEM Cover required for moisture-proofing. Weight is reported in AGC weight value.

Alignment Optical Telescope (AOT)

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

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

Bellows Assembly

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

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

Book of Procedures

CM Not in CM; see MDV.

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

Coupling Data Unit (CDU) Assembly

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

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

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

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

Cold Plates

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

Control Electronics Assembly

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

CM BLOCK II May be relocated with other similar functions.

LEM Not defined in LEM.

Coolant Hoses

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

LEM Not identified as part of LEM.

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

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

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

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

D&C Electronics Assembly

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

CM BLOCK II Not defined at this time.

LEM Not defined in LEM at this time.

Eye Register for Reticule

CM Not in CM.

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

Film Cartridges

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

LEM Does not exist in LEM.

G&N Indicator Control Panel

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

LEM Does not exist in LEM.

G&N Interconnection Assembly

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

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

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

G&N to S/C Interface Assembly

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

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

LEM Not identified yet as a separate item in LEM.

Horizon Photometer

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

LEM Not a part of LEM.

Horizon Photometer Electronics

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

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

LEM Not required.

Inertial Measurement Unit (IMU)

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

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

IMU Control Panel

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

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

LEM Does not exist in LEM.

Long-Eye-Relief Eyepieces

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

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

Map and Data Viewer (MDV)

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

LEM Not in LEM; see Book of Procedures.

NVB and Resilient Mounts

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

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

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

Optical Eyepieces

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

LEM Included as part of the AOT.

Optical Subsystem

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

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

LEM Not in LEM; see AOT.

Optical Shroud & Cover Assembly

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

LEM Does not exist in LEM.

Power Servo Assembly (PSA)

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

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

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

PSA End Connector Assembly

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

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

PSA Covers

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

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

LEM Same as Block II except lighter in weight.

Signal Conditioner Assembly

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

Two-Digit Readout for Reticle

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.