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GUIDANCE AND NAVIGATION

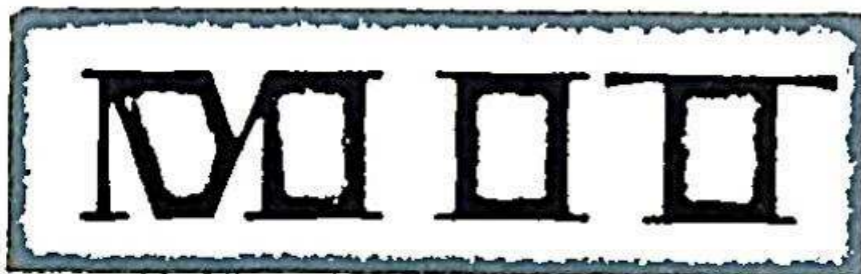
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E-1142 (REV. 9)
(UNCLASSIFIED TITLE)
WEIGHT AND BALANCE
REPORT

June 15, 1963

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ABSTRACT

Report E-1142 (Rev. 9) presents weight, center of gravity, and moment of inertia values for all components of the Command Module guidance and navigation equipment. Component design load weights have been included.

Power requirements of the Command Module guidance and navigation equipment upon the Primary +28 VDC Power Supply are also included.

In addition, this report presents weight estimates of the Lunar Excursion Module G&N equipment.

E-1142 is prepared monthly and distributed on the 15th of each month.

Introduction

E-1142 (Rev. 9) is submitted in compliance with the documentation requirement of weight, center of gravity, and moment of inertia data for Apollo guidance and navigation equipment.

Component design load weights are submitted as worst case values for structural design.

Power requirements, for Apollo guidance and navigation equipment, have been included to aid in the determination of spacecraft primary power.

Weights

All weight items are grouped according to their specific location within the spacecraft modules. Subsystem weights are reported to the component level and to the nearest tenth of a pound.

Given component weights are identified as calculated, measured, or estimated. These terms are defined by North American Aviation as follows:

Calculated weights (C) are weights 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.

Estimated weights (E) are rough calculations.

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

Weight Status Reporting

Table 1 offers a comparison of present weight values of Command Module

components with those listed in the previous Weight and Balance Report, E-1142 (Rev. 8), May 15, 1963. All weight changes are explained.

The "Spec. Weight" column contains "proposed MSC" weights, that is, goals set forth by MSC in a memo to MIT/IL dated December 5, 1962.

The "Design Load Weight" column contains assigned worst estimate design weights 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 #8, that one total weight figure for supported G & N load be assigned for structural design use. MIT/IL herein assigns a total G & N design load weight in table 1, which does not include items termed "loose stored items".

Table 3 presents estimated weights of LEM G&N equipment.

Center of Gravity

The centers of gravity of each weight component or packaged assembly are determined with respect to the basic X, Y, Z axes of the Command Module which are shown in figure 1. Center of gravity values, for Command Module components, are given to the nearest tenth of an inch and are shown in table 2.

Moments of Inertia

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

Accuracy

The accuracy of numerical values reported in this revision should not be considered to be within the tolerance implied by the significant figures quoted. Numerical values will approach the established tolerances as design and development phases approach completion.

Power Requirements

The electrical load of the Command Module guidance and navigation equipment, on the Primary +28 VDC Power Supply, is shown in figure 2.

Explanation of Reported Weight Changes

IMU Control Panel - Weight reduction due to (1) a reduction in panel skin thickness from 0.030 inches to 0.020 inches and (2) a change of CDU Mode Control from mechanical interlock to relay interlock.

D & C Electronics Module - Weight increase due to design change of Mode Switch on IMU Control Panel from mechanical interlock to relay interlock. This change resulted in the addition of six relays and six diodes to the Relay and Diode Module and a packaging redefinition.

G & N Indicator Control Panel - Weight increase due to (1) the use of a solenoid held switch instead of a mechanical switch for the Attitude Disable Switch (2) the addition of more poles to the Map-Data Slew Switch and (3) the additional circuit definition of the Transformer and the Resistor Module.

Eye Relief Eyepieces - Weight decrease due to a better estimate based upon a detailed weight calculation.

Possible Future Weight Changes

IMU - Failure of two stub shafts in recent IMU 2 shake tests will probably result in a thickness increase of six stub shafts. About one-tenth of a pound increase is anticipated.

CBL - Cabling will probably increase in weight due to the extra cabling required for the Signal Conditioning Electronics module and the D & C Electronics module.

AGC - A possible twenty-five pound weight reduction may be realized if the present LEM computer configuration is used in the Command Module.

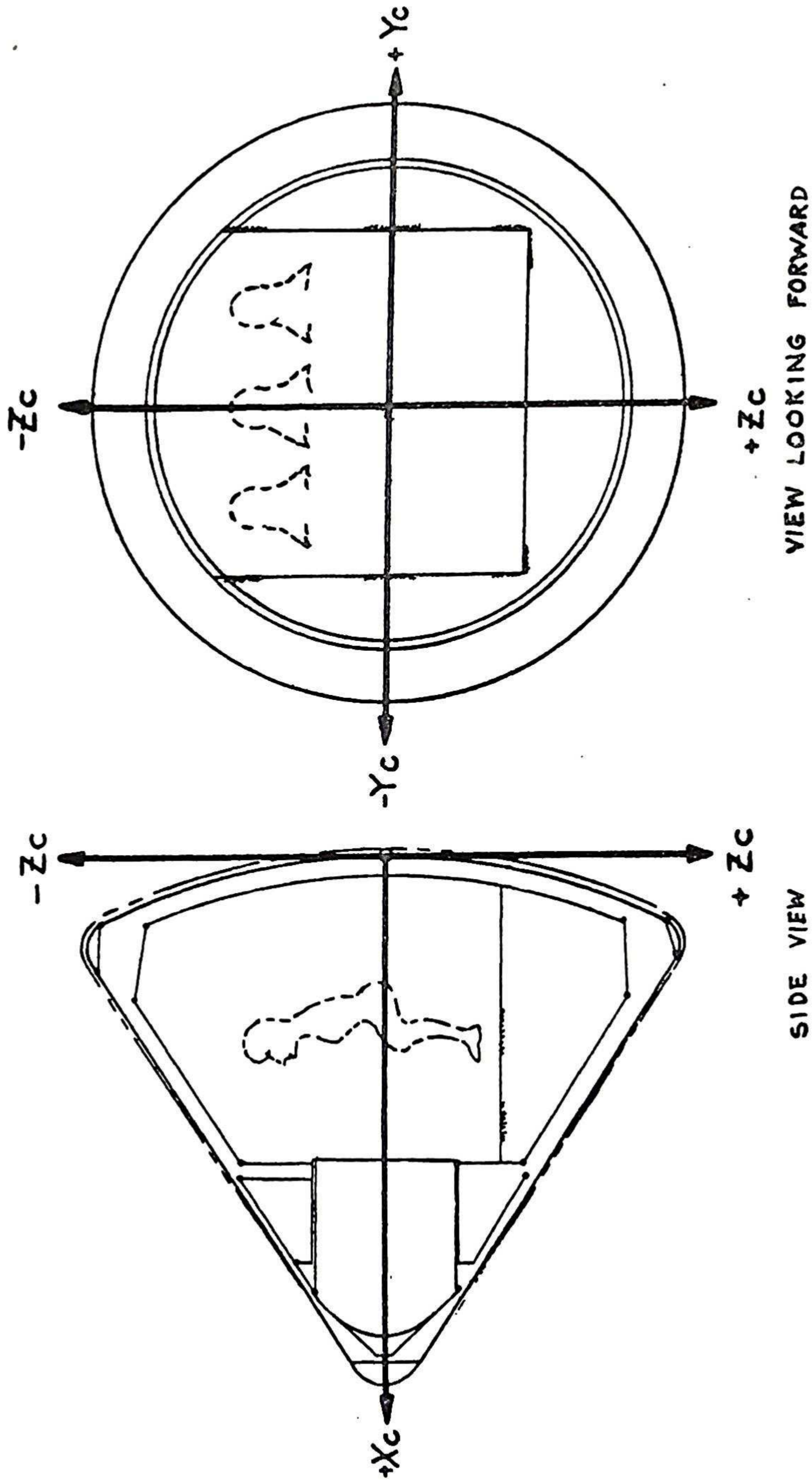


Figure 1. X, Y, Z Axes of Command Module

Table 1. Command Module Current Weight Status (lbs)

Item	Spec. Wt. 12/62 (a)	(b-a)	Status 5/63 (b)	(c-b)	Status 6/63 (c)	Design Load Wt. 5/63 (d)
<u>LOWER EQUIPMENT BAY</u>						
CDU & Frame Assy	6.0	+ 10.5	16.5	0.0	16.5(E)	17.2
Optical Subsystem						
SXT	12.0	0.0	12.0	0.0	12.0(E)	154.2
SCT	9.0	0.0	9.0	0.0	9.0(E)	
Optical Base & Gearing	14.0	+ 7.0	21.0	0.0	21.0(E)	
Optical Eyepieces						
SXT	2.0	+ 1.8	1.5	0.0	1.5(E)	
SCT			2.3	0.0	2.3(E)	
IMU	40.0	+ 19.0	59.0	0.0	59.0(E)	
NVB & Shock Mounts	16.0	+ 11.2	27.2	0.0	27.2(E)	
Bellows Assy	8.0	+ 5.9	13.9	0.0	13.9(E)	
Cabling	22.0	+ 3.0	25.0	0.0	25.0(E)	27.2
D & C Nav Station						
IMU Control Panel			6.0	-1.6	4.4(E)	6.8
D&C Electronics Module			3.2	+2.4	5.6(E)	7.7
Optical Shroud	30.0	- 6.8	3.8	0.0	3.8(E)	4.2
G&N Ind Cont Panel	15.0	0.0	10.2	+1.7	11.9(E)	13.2
D & C/AGC	5.0	+ 3.5	15.0	0.0	15.0(E)	19.4
M & DV (including 1 film)			8.5	0.0	8.5(E)	10.0
AGC (no spares)			93.0	0.0	93.0(E)	126.4
Spares Tray	80.0	+ 28.0	4.0	0.0	4.0(E)	
Stored Spares			11.0	0.0	11.0(E)	65.0
PSA	25.0	+ 32.2	54.7	0.0	54.7(E)	
Stored Spares			2.5	0.0	2.5(E)	

(Continued)

Table 1. Command Module Current Weight Status (lbs) (Cont'd)

Item	Spec. Wt. 12/62 (a)	(b-a)	Status 5/63 (b)	(c-b)	Status 6/63 (c)	Design Load Wt. 5/63 (d)		
JBX	8.0	+ 4.2	12.2	0.0	12.2(E)	15.6		
<u>MAIN PANEL AREA</u>								
D & C/AGC	5.0	+ 10.0	15.0	0.0	15.0(E)	17.2		
D & C/NAV	8.0	- 8.0	--	--	--	--		
<u>LOOSE STORED ITEMS</u>								
Eye Relief Eyepieces	--	+ 2.0	2.0	-0.5	1.5(E)	--		
Film Cartridges (4)	--	+ 3.0	3.0	0.0	3.0(E)	--		
AGC Loose Spares	20.0	+ 18.0	26.0	0.0	26.0(E)	--		
PSA Loose Spares							9.0	9.0(E)
CDU Spare Gearbox							3.0	3.0(E)
Computer Self-Check Plug	--	+ 1.0	1.0	0.0	1.0(E)	--		
Horizon Photometer	--	+ 4.0	4.0	0.0	4.0(E)	--		
Spare Lamps (3)	--	+ 0.2	0.2	0.0	0.2(E)	--		
Spare Relay & Diode Module	--	+ 0.3	0.3	0.0	0.3(E)	--		
TOTAL	325.0	+150.0	475.0	+ 2.0	477.0			
TOTAL (exclusive of "Loose Stored Items")					429.0	484.1		

APOLLO G & N WEIGHT & BALANCE REPORT

E-1142

Table 2. Command Module Center of Gravity and Moment of Inertia Data

Item	Weight (lbs)	Center of Gravity (inches)			Moment of Inertia (lb-in ²)		
		X	Y	Z	I _{xx}	I _{yy}	I _{zz}
COMMAND MODULE							
<u>Lower Equip. Bay</u>							
CDU & Frame Assy	16.5(E)	63.5	- 14.4	35.8	50	470	470
Optical Subsystem							
SXT	12.0(E)	70.5	- 3.5	34.7			
SCT	9.0(E)	70.5	5.5	34.7			
Opt. Base & Gearing	21.0(E)	67.9	0.0	30.7			
Optical Eyepieces							
SXT	1.5(E)	65.1	- 3.5	26.2			
SCT	2.3(E)	65.1	4.5	26.2			
IMU	59.0(E)	56.6	0.0	41.7	1330	1330	1330
NVB & Shock Mounts	27.2(E)	60.6	0.0	44.0			
Bellows Assy	13.9(E)	71.5	- 0.3	36.3			
Cabling	25.0(E)						
D & C/NAV Station							
IMU Cont Panel	4.4(E)	74.0	- 15.4	30.9			
D & C Electronics Module	5.6(E)	49.5	- 9.6	39.6			
Optical Shroud	3.8(E)	66.8	0.0	28.9			
G&N Ind. Control Pnl	11.9(E)	54.1	0.1	33.9			
D & C/AGC	15.0(E)						
M & DV (includes 1 film)	8.5(E)	73.5	- 4.5	31.0			
AGC (no spares)	93.0(E)	37.0	0.0	45.0	7750	4860	3250
Spares Tray	4.0(E)	40.5	0.0	45.0		760	110
Stored Spares	11.0(E)	40.5	0.0	45.0			

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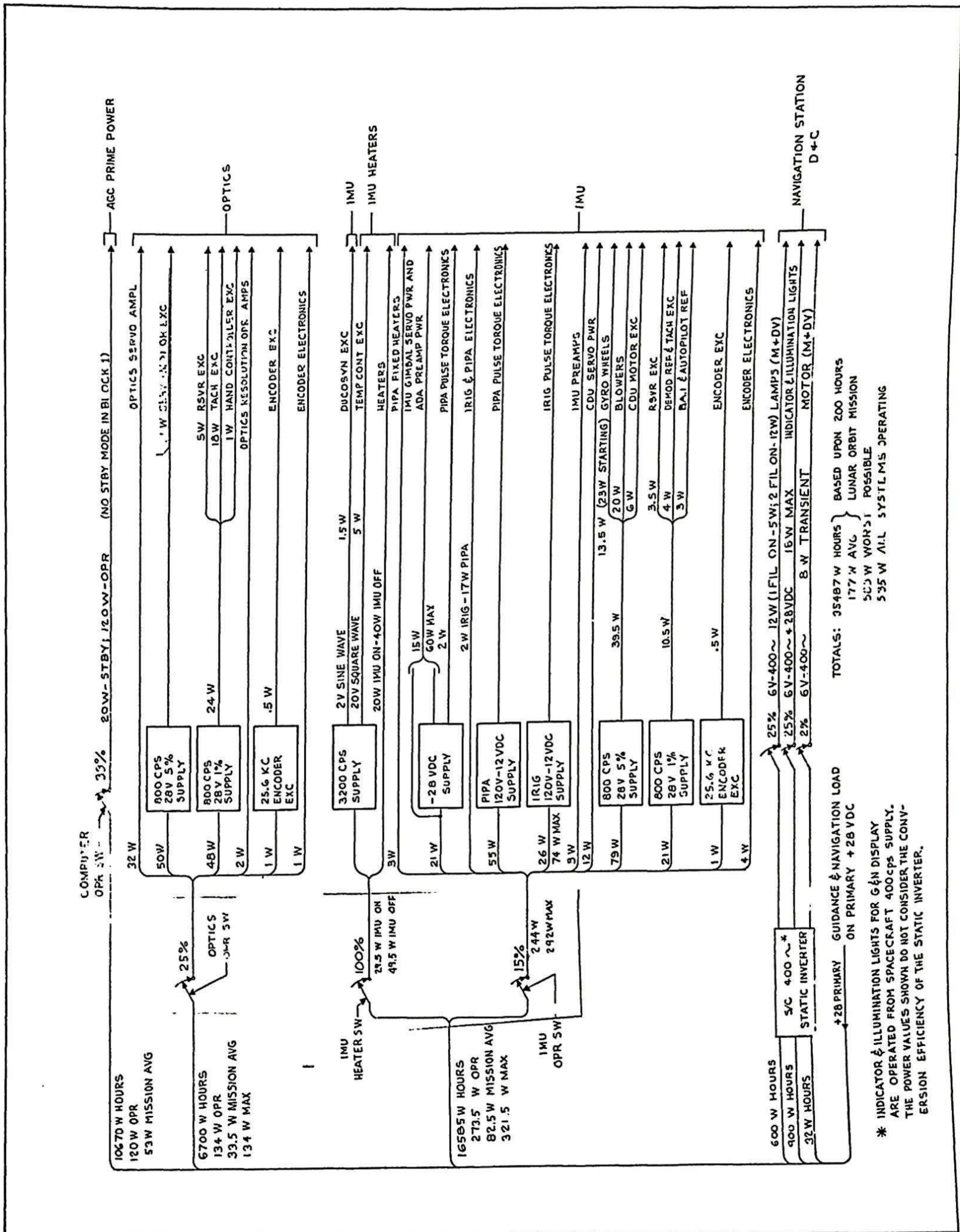


Figure 2. Electrical Load on Primary + 28 VDC

Glossary

- AGC: Apollo Guidance Computer: complete computer, except display and keyboard. Includes: - all structural mounting rails, support for spare tray, AGC cable to front panel for spacecraft electrical interface, spare logic in four trays, and power supply.
- BELLOWS ASSEMBLY: Bellows Assembly: connection between Command Module and Optical Subsystem consisting of SXT and SCT bellows plus bellows seals.
- CABLING: Cabling: intrasubassembly cabling in lower equipment bay. (Interequipment cabling from lower equipment bay to other assemblies is assumed a spacecraft responsibility.)
- CDU & FRAME ASSEMBLY: Coupling Display Units and frame assembly: five gear boxes and frame assembly, used as an angle data interface among the optics, IMU, AGC, and spacecraft autopilot.
- D&C/AGC: Display and Control, Computer: letter and number readout, keyboard, control, relays, and support structure.
- D&C/NAV: Display and Control, Navigation: consists of G & N Indicator Control Panel, IMU Control Panel, D & C Electronics Module, and Optical Shroud. The above includes meters, switches, lights, etc. except as reported elsewhere. The weight does not include the clock group which is supplied by NAA.
- G&N Ind Cont Panel: G&N Indicator Control Panel: consists of the necessary switches, indicators, and controls for the navigation task not reported elsewhere. Includes optics hand controller, altitude impulse control, panel wiring, and supporting hardware.

IMU Cont Panel: IMU Control Panel: meter, switches, panel wiring and supporting hardware.

D & C Electronics Module: D & C Electronics Module: contains six electronic modules.

Optical Shroud & Cover Assy: : Optical Shroud & Cover Assembly: optical shroud and protective cover.

EYE RELIEF EYEPIECES: Eye Relief Eyepieces: a SXT and a SCT eyepiece to provide eye relief of at least 1.6 inches for closed visor operation.

FILM CARTRIDGES: Film Cartridges: film cartridges, including film, for Map and Data Viewer.

HORIZON PHOTOMETER: Horizon Photometer: an automatic, photometric, horizon detector device interchangeable with sextant eyepiece to provide capability for use of earth's illuminated limb as a navigation reference.

IMU: Inertial Measurement Unit: gimbal assembly, inertial components, data transducers, support structure, and internal cooling.

JUNCTION BOX: Junction Box: electrical interconnection center between subassemblies in lower equipment bay.

M&DV: Map and Data Viewer: film viewer for display of maps, charts, procedures, etc. Weight includes one film cartridge with film.

NVB & SHOCK MOUNTS: Navigation Base and Shock Mounts: rigid structure supporting the IMU and the Optical Subsystem with its associated hardware and supported by three shock mounts that attach the NVB to the spacecraft.

OPTICAL EYEPIECES: Optical Eyepieces: optical eyepieces for SXT and SCT.

OPTICAL SUBSYSTEM:

Optical Subsystem: SXT, SCT, Optical Base and gearing, panel base, and associated hardware.

Optical Base & Gearing:

Optical Base and Gearing: base for SCT and SXT with associated gearing.

SCT:

Scanning Telescope: single line-of-sight, wide-field, two-degree-of-freedom telescope and its attached gearing.

SXT:

Sextant: two line-of-sight, narrow field, two-degree-of-freedom sextant, including attached gearing and internal cooling.

PSA:

Power Servo Assembly: IMU, SCT, and SXT servos, power supplies, CDU electronics, IMU backup mode electronics, Signal Conditioning electronics, and miscellaneous electronics.

APOLLO G & N WEIGHT & BALANCE REPORT

E-1142

LEM WEIGHTS

Table 3. Estimated Weights of LEM G & N Components
Preliminary Estimate Given to Lewis (ASPO) Based Upon Scanning Telescope
18 April 1963
Latest Estimate Based Upon Fixed Telescope Installation
21 May 1963

Component	Preliminary Estimate Given to Lewis (ASPO) Based Upon Scanning Telescope 18 April 1963	Latest Estimate Based Upon Fixed Telescope Installation 21 May 1963
3 CDUs and mounting	7	-
5 CDUs and mounting	-	16
Scanning telescope, gearbox and frame, and normal eyepiece	35	-
Eye relief eyepiece for SCT	5	-
Fixed alignment telescope, frame, normal eyepiece, and eye relief eyepiece	-	12
Eye register device for reticule	-	2
Nav Base not including effect of hull penetration or window	20	4
IMU	58	58
Cable (installation not identified)	40	-
Cable (assuming wiring between widely separated subsystems is spacecraft cable and reported elsewhere)	-	15
Display & Controls	25	20
D&C for Computer	15	15

LEM WEIGHTS

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LEM WEIGHTS

Table 3. Estimated Weights of LEM G & N Components (Cont'd)

Component	Preliminary Estimate Given to Lewis (ASPO) Based Upon Scanning Telescope 18 April 1963	Latest Estimate Based Upon Fixed Telescope Installation 21 May 1963
Book for procedures, charts, etc.	2	2
AGC, 5 tray CM configuration including 1 tray stored spares	108	-
AGC, 3 tray new configuration including 1 tray stored spares and new LEM junction box	-	60
PSA, with CM Type J box	60	-
PSA, using common J box and reduced trays	-	35
Cold plate, common use between AGC and PSA	-	5
TOTAL	375	244

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