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APOLLO

GUIDANCE AND NAVIGATION

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E-1142 (REV. 5)
File

WEIGHT AND BALANCE REPORT

February 15, 1963

MIT INSTRUMENTATION LABORATORY
CAMBRIDGE 39, MASSACHUSETTS

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ABSTRACT

Report E-1142 (Rev. 5) presents weight, center of gravity, and moment of inertia values for all components of the guidance and navigation equipment.

Power requirements of the guidance and navigation equipment upon the Primary +28VDC Power Supply have also been included.

Only data pertaining to the command and service modules is, at present, included in this report.

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

Introduction

E-1142 (Rev. 5) is submitted in compliance with the documentation requirement of weight, center of gravity, and moment of inertia data for Apollo guidance and navigation equipment. At present, however, E-1142 pertains to only the command and service module.

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. The internal cooling for the sextant and IMU are included in the weights reported for these items.

Weight Status Reporting

Table 1 offers a comparison of present weight values with those listed in the previous Weight and Balance Report, E-1142 (Rev. 4), January 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.

Centers 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 are given to the nearest tenth of an inch and are shown in table 2.

Moments of Inertia

The moments of inertia are calculated about the basic X, Y, Z axes of the command module and are shown in table 2. Component weights are assumed concentrated at their centers of gravity. Moments of inertia were thus determined by multiplying the component weight (at its center of gravity) by the square of the distance from the component's center of gravity to the X, Y, and Z axes.

More accurate moment of inertia data will be supplied in subsequent reports.

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. Numerical values will approach the established tolerances as design and development phases approach completion.

Power Requirements

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

Explanation of Reported Weight Changes

NVB - Weight increase due to changes in NVB frame and addition of miscellaneous hardware.

IMU - Further evaluation has produced a reduction in the current weight value.

Anticipated Changes in Weight and Balance Report

This revision of the weight and balance report was prepared during considerable activity in negotiations of mechanical interfaces between the guidance and navigation equipment and the spacecraft structure.

As a result, a number of significant design changes will be reflected in future weight and balance reports. Specifically, the center of gravity of the AGC will be moved down (smaller value of "X") by several inches and the weight of this and the PSA will increase to account for 13 pounds of stored AGC and PSA spare electronics modules in this area. The remaining 27 pounds of estimated spares are termed "loose" spares and will be stored in some other, as yet undetermined, location.

APOLLO G & N WEIGHT & BALANCE REPORT E-1142

A non-visual eyepiece ...horizon photometer ... has been identified, for some time, for use of the earth's illuminated limb as a navigation reference. It has not appeared in the report as a separate item. An estimate of 4 pounds weight and a storage volume of 3x6x6 inches has been made.

A further weight increase in the optical visual eyepiece is anticipated in response to a NASA request, dated 1 February 1963, that the minimum eye relief distance be increased to 1.6 inches without the use of devices integral with the helmet. A rough estimate of 3 pounds increase is made tentatively for the bigger eyepieces assuming the 3 power magnification of the telescope is eliminated.

Storage of extra film canisters for the M&DV may be required with a resulting weight increase.

These weight changes will be more fully evaluated in the next weight report.

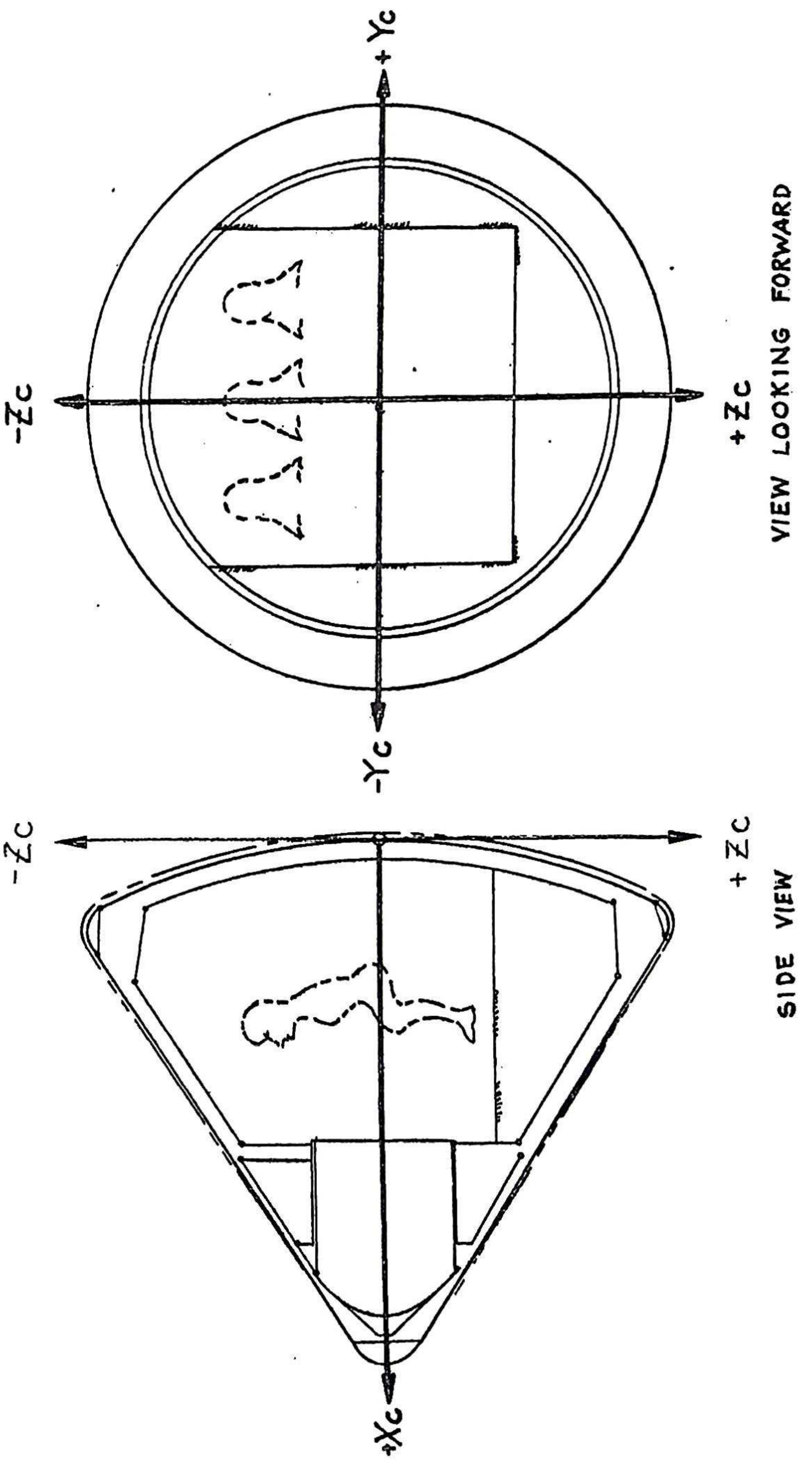

Figure 1. X, Y, Z axes of Command Module

Table 1. Current Weight Status (lbs)

Items	Spec. Wt. 12/62	Changes to 12/62 Spec. Wt.	Status 1/63	Changes to 1/63 Status	Current Weight 2/63
COMMAND MODULE					
Lower Equip. Bay - Forward					
CDU	6.0	0.0	15.0(E)	0.0	15.0(E)
OPT SUBSYSTEM	35.0	0.0	40.0(E)	0.0	40.0(E)
IMU	50.0	0.0	58.7(E)	-0.4	58.3(E)
NVB	16.0	0.0	21.0(E)	+3.0	24.0(E)
BELLOWS ASSY	8.0	0.0	15.0(E)	0.0	15.0(E)
OPT EYE PIECES	2.0	0.0	5.0(E)	0.0	5.0(E)
CBL	22.0	0.0	40.0(E)	0.0	40.0(E)
D&C/NAV	30.0	0.0	31.5(E)	0.0	31.5(E)
D&C/AGC	15.0	0.0	15.0(E)	0.0	15.0(E)
M&DV	5.0	0.0	8.5(E)	0.0	8.5(E)
Lower Equip. Bay - Middle					
AGC	80.0	0.0	58.0(E)	0.0	58.0(E)
PSA*	25.0	0.0	29.0(E)	0.0	29.0(E)
JBX	8.0	0.0	11.0(E)	0.0	11.0(E)
Main Panel					
D&C/NAV	8.0	0.0	10.0(E)	0.0	10.0(E)
D&C/AGC	5.0	0.0	15.0(E)	0.0	15.0(E)
SERVICE MODULE					
RAD	15.0	0.0	15.0(E)	0.0	15.0(E)
SPARES	20.0	0.0	40.0(E)	0.0	40.0(E)
TOTAL	350.0	0.0	427.7	+2.6	430.3

Notes: (C) Calculated; (E) Estimated; (M) Measured.
*PSA weights are based on old CDU configuration.

Table 2. Center of Gravity and Moment of Inertia Data

Item	Weight (lbs)	Center of Gravity (inches)			Moment of Inertia ($lb\text{-}in^2$)		
		X	Y	Z	I_{xx}	I_{yy}	I_{zz}
COMMAND MODULE							
Lower Equip. Bay, Forward							
CDU	15.0(E)	63.5	-14.4	35.8	22,200	80,000	63,500
OPT SUBSYSTEM	40.0(E)	69.0	1.7	32.3	42,000	231,800	190,000
IMU	58.7(E)	56.6	0.0	41.7	102,000	290,000	188,000
NVB	24.0(E)	60.6	0.0	44.0	46,600	134,000	88,000
BELLOWS ASSY	15.0(E)	71.0	- 0.2	35.6	19,100	109,500	76,000
OPT EYE PIECES**							
SXT	1.0(E)	65.1	- 3.5	26.2	700	4,930	4,260
SCT	4.0(E)	65.1	4.5	26.2	2,820	19,800	17,100
CBL*	40.0(E)						
D&C/NAV	31.5(E)	63.2	- 4.3	33.1	35,000	160,000	126,500
D&C/AGC	15.0(E)						
M&DV	8.5(E)						
Lower Equip. Bay, Middle							
AGC	58.0(E)	39.2	0.0	50.0	145,000	234,000	89,000
PSA	29.0(E)	44.7	0.0	41.3	49,000	107,500	58,000
JBX	11.0(E)	44.9	0.0	50.0	27,500	49,600	22,100
Main Panel							
D&C/NAV	10.0(E)						
D&C/AGC	15.0(E)						
SERVICE MODULE							
RAD*	15.0(E)						
SPARES	40.0(E)						

*C. g. values for these items not determined due to indefinite location

**C. g. values are given for eyepieces mounted in place in SXT and SCT; storage location approximately: X=78.25, Y=left hand forward equipment bay. Z=27.9

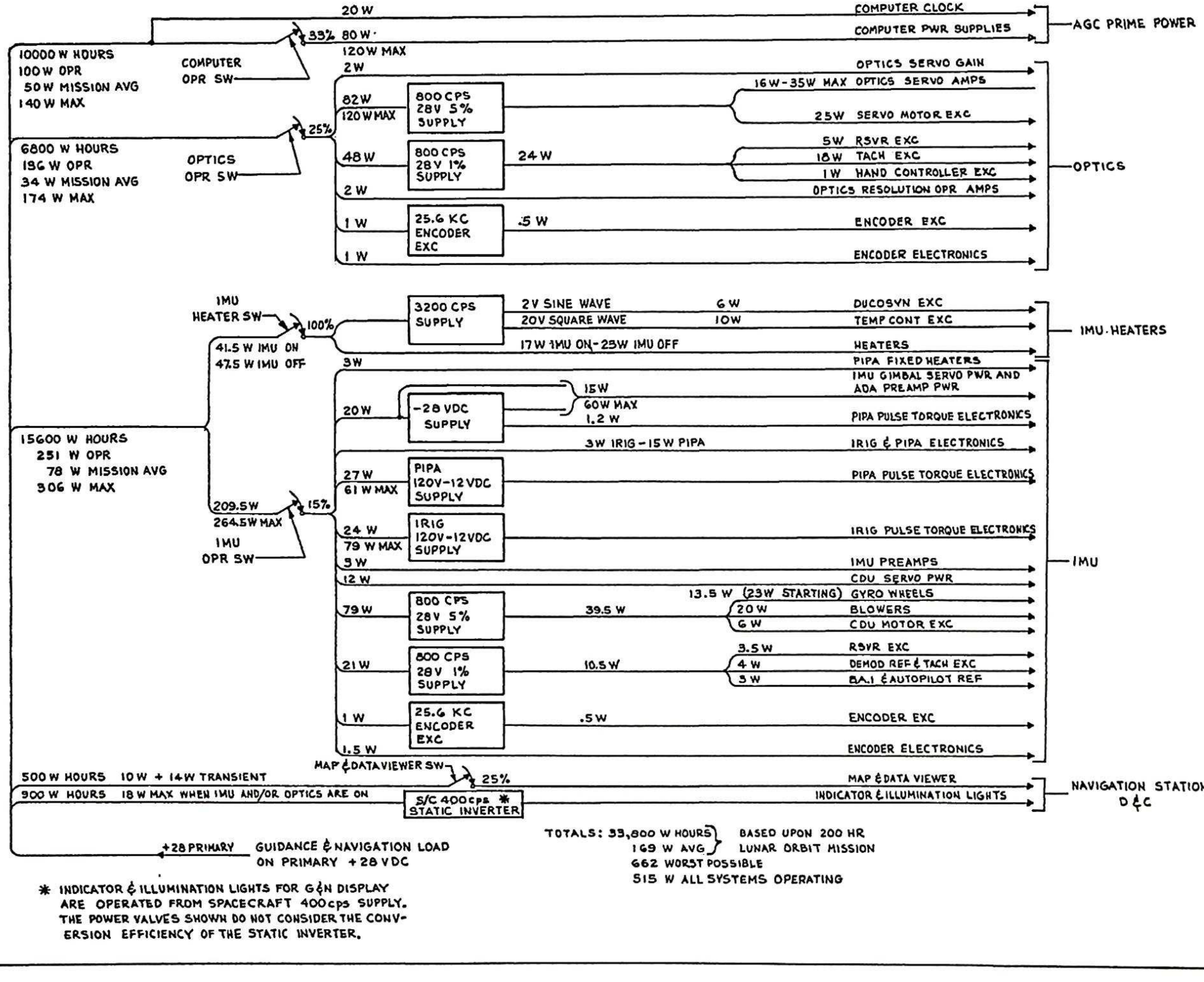

Figure 2. Electrical Load on Primary + 28 VDC

Glossary

AGC:	Apollo Guidance Computer: complete computer, except display and keyboard, including all structure mounting rails.
BELLOWS ASSY:	Bellows Assembly: connection between command module and optical subsystem.
CBL:	Cabling: intrasubassembly cabling in lower equipment bay. (Interequipment cabling from lower equipment bay to other assemblies is assumed a spacecraft responsibility.)
CDU:	Coupling Display Units: five gear boxes 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: meters, switches, lights, etc. except as reported elsewhere. Weight includes display panel in lower equipment bay but does not include wire, clock, or optics controller gear train. The display clock is not considered as part of the G&N equipment even though it appears above the G&N display panel.
IMU:	Inertial Measurement Unit: gimbal assembly, inertial components, data transducers, and support structure.
JBX:	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.
NVB:	Navigation Base: rigid structure supporting the IMU and the optical subsystem with its associated hardware and supported by three shock mounts.

OPT. BASE:	Optical Base: Base for SCT and SXT.
OPT. EYE PIECES:	Optical Eye Pieces: optical eye pieces for SXT and SCT.
OPT. SUBSYSTEM:	Optical Subsystem: SXT, SCT, optical base, panel base, and associated hardware.
PSA:	Power Servo Assembly: IMU, SCT, and SXT servos, power supplies, CDU electronics, IMU backup mode electronics, and miscellaneous electronics.
RAD:	Radar: Electromagnetic ranging equipment, located in service module, for lunar orbit rendezvous.
SCT:	Scanning Telescope: single line-of-sight, wide-field, two-degree-of freedom telescope and its drive mechanism.
SHOCK MOUNTS:	Three shock mounts that attach the NVB to the spacecraft.
SXT:	Sextant: two line-of-sight, narrow field, two-degree-of freedom sextant, and drive mechanism.

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