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APOLLO

GUIDANCE AND NAVIGATION

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SYSTEM STATUS REPORT
August 1963



INSTRUMENTATION LABORATORY

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ABSTRACT

This is the first monthly report of the System Status Report (E-1142, Rev. 11) which replaces the Weight and Balance Report, the last edition of which was E-1142, Rev. 10 dated 15 July 1963.

Included in this report are; (1) weights, centers of gravity, and moments of inertia of G & N components in the Command Module, (2) weights of G & N components in the Lunar Excursion Module, and (3) power requirements of Command Module equipment upon the Primary +28 VDC Power Supply.

Section 1

INTRODUCTION

1-1 INTRODUCTION

The System Status Report, as the name implies, will eventually present, monthly, all information concerning the status of the Apollo Guidance and Navigation System.

At present, however, only the following information is contained in this report: (1) weights, centers of gravity, and moments of inertia of G & N components in the Command Module, (2) weights of G & N components in the Lunar Excursion Module, and (3) power requirements of Command Module equipment upon the Primary +28 VDC Power Supply.

1-2 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 tolerance as design and development phases approach completion.

Section 2

COMMAND MODULE WEIGHT DATA

2-1 WEIGHTS

Table 2-1 presents all weight items, grouped according to their specific location within the Command Module. Subsystem 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 rough calculations. 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.

Since all weight values now reported may be classified as only estimated weights MIT herein affixes a prime to the (E) symbol, i. e., (E¹) to denote, for various reasons, values which MIT feels to be more accurate than estimated values, yet not able to comply with the definitions of calculated and measured weights.

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

2-1.1 WEIGHT STATUS REPORTING. Table 2-1 also offers a comparison of present component weight values with those listed in Weight and Balance Report, E-1142 (Rev. 10), July 15, 1963. All weight changes are explained (see 2-2).

2-1.2 SPEC. WEIGHT. The "Spec. Weight" column in table 2-1 contains "proposed MSC" weights, that is, goals set forth by MSC in a memo to MIT dated December 5, 1962.

2-1.3 DESIGN LOAD WEIGHT. The "Design Load Weight" column contains 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 herein assigns a total G&N design load weight, in table 2-1, which does not include items termed "loose stored items".

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Table 2-1. Current weight status of Command Module (lbs)

| Item | Spec. Wt. 12/62 (a) | (b-a) | Status 7/63 (b) | (c-b) | Status 8/63 (c) | Design Load Wt. 8/63 (d) |
|-----------------------------|---------------------------|--------|-----------------------|-------|-----------------------|-----------------------------------|
| LOWER EQUIPMENT BAY | | | | | | |
| 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 ¹) | 154.2 |
| SCT | | | 2.3 | 0.0 | 2.3(E ¹) | |
| IMU | 40.0 | + 19.0 | 59.0 | 0.0 | 59.0(E ¹) | |
| NVB & Shock Mounts | 16.0 | + 11.2 | 27.2 | 0.0 | 27.2(E) | |
| Bellows Assy | 8.0 | + 4.6 | 12.6 | 0.0 | 12.6(E) | |
| Interconnect Wiring Harness | 22.0 | + 13.0 | 35.0 | 0.0 | 35.0(E) | 27.2 |
| D & C Nav Station | | | | | | |
| IMU Control Panel | | | 4.4 | 0.0 | 4.4(E ¹) | 6.8 |
| D&C Electronics Module | | - 4.6 | 5.6 | + 1.0 | 6.6(E ¹) | 7.7 |
| Optical Shroud | 30.3 | | 3.8 | 0.0 | 3.8(E ¹) | 4.2 |
| G & N Ind Cont Panel | | | 11.9 | 0.0 | 11.9(E ¹) | 13.2 |
| D & C/AGC | 15.0 | 0.0 | 15.0 | 0.0 | 15.0(E) | 19.4 |
| M & DV (including 1 film) | 5.0 | + 3.5 | 8.5 | 0.0 | 8.5(E) | 10.0 |
| AGC (no spares) | 80.0 | + 15.0 | 70.0 | 0.0 | 70.0(E) | 126.4 |
| Spare Tray | | | 25.0 | + 1.5 | 26.5(E) | |
| PSA | 25.0 | + 32.2 | 54.7 | + 2.0 | 56.7(E) | 65.0 |
| Stored Spares | | | 2.5 | - 2.5 | 0.0 | |
| JBX | 8.0 | + 4.2 | 12.2 | 0.0 | 12.2(E) | 15.6 |
| Coolant Hoses | 0.0 | 0.0 | 0.0 | + 1.0 | 1.0(E) | |

(Continued)

CM

Table 2-I. Current weight status of Command Module (lbs) (con't.)

| Item | Spec. Wt. 12/62 (a) | (b-a) | Status 7/63 (b) | (c-b) | Status 8/63 (c) | Design Load Wt. 8/63 (d) |
|---|---------------------------|---------|-----------------------|-------|-----------------------|-----------------------------------|
| <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 | -- | + 1.5 | 1.5 | 0.0 | 1.5(E) | |
| Film Cartridges (4) | -- | + 3.0 | 3.0 | 0.0 | 3.0(E) | |
| AGC Loose Spares | | | 26.0 | - 9.0 | 17.0(E) | |
| PSA Loose Spares | 20.0 | + 18.0 | | + 2.5 | 11.5(E) | |
| CDU Spare Gearbox | | | 3.0 | 0.0 | 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 | + 143.7 | 472.7 | - 3.5 | 469.2 | |
| TOTAL (Exclusive of "Loose Stored Items") | | | 424.7 | + 3.0 | 427.7 | 484.1 |

2-2 EXPLANATION OF REPORTED WEIGHT CHANGES

Component weight changes shown in column (c-b) of table 2-I are explained below.

2-2.1 D & C ELECTRONICS MODULES. As a result of NASA Coordination Meeting #10, a step down transformer has been added to convert 115V 400 cps power supplied by North American to proper voltages for the M & DV and indicator and illumination lights.

2-2.2 AGC (SPARE TRAY AND LOOSE SPARES). Present computer sparing philosophy calls for a complete spare logic tray which accounts for the increase in weight of the AGC Spare Tray. Several components of the Logic Tray were weighed. AGC Loose Spares weight decreased nine pounds. The new weight accounts only for sparing of all unique modules in the memory tray.

2-2.3 PSA. Also as a result of NASA Coordination Meeting #10, an extra 800 cps 5% amplifier module has been added in PSA tray 10 to meet NAA cold-plate requirements. The module and the extra support structure required for the module each weigh one pound.

2-2.4 PSA (STORED SPARES AND LOOSE SPARES). Since the PSA no longer has any room to store spares, these spares are now added to the spares called "PSA Loose Spares."

2-3 CENTERS OF GRAVITY

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

2-4 MOMENTS OF INERTIA

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

CM

Table 2-II. Command Module center of gravity and moment of inertia data

| Item | Weight (lbs) | Centers of Gravity (inches) | | | Moments of Inertia (lb-in ²) | | |
|-----------------------------|--------------|-----------------------------|--------|------|--|------|-------|
| | | X | Y | Z | Ixx | Iyy | Izz |
| <u>LOWER EQUIPMENT BAY</u> | | | | | | | |
| CDU & Frame Assy | 16.5 | 63.5 | - 14.4 | 35.8 | 50 | 470 | 470 |
| Optical Subsystem | | | | | | | |
| SXT | 12.0 | 70.5 | - 3.5 | 34.7 | | | |
| SCT | 9.0 | 70.5 | 5.5 | 34.7 | | | |
| Opt. Base & Gearing | 21.0 | 67.9 | 0.0 | 30.7 | | | |
| Optical Eyepieces | | | | | | | |
| SXT | 1.5 | 65.1 | - 3.5 | 26.2 | 5 | 10 | 5 |
| SCT | 2.3 | 65.1 | 4.5 | 26.2 | 10 | 10 | 10 |
| IMU | 59.0 | 56.6 | 0.0 | 41.7 | 1330 | 1330 | 1330 |
| NVB & Shock Mounts | 27.2 | 64.3 | - 0.1 | 41.3 | 3270 | 4050 | 5210 |
| Bellows Assy | 12.6 | | | | | | |
| Interconnect Wiring Harness | 35.0 | 56.9 | 0.0 | 42.5 | 9410 | 5130 | 11500 |
| D & C/NAV Station | | | | | | | |
| IMU Cont Panel | 4.4 | 74.0 | - 15.4 | 30.9 | 20 | 40 | 30 |
| D & C Electronics Module | 6.6 | 49.5 | - 9.6 | 39.6 | 40 | 40 | 15 |
| Optical Shroud | 3.8 | 66.8 | 0.0 | 28.9 | 280 | 60 | 300 |
| G & N Ind. Control Pnl | 11.9 | 54.1 | 0.1 | 33.9 | 560 | 150 | 720 |
| D & C/AGC | 15.0 | | | | | | |
| M & DV (includes 1 film) | 8.5 | 73.5 | - 4.5 | 31.0 | | | |
| AGC (no spares) | 70.0 | 37.8 | 1.3 | 46.1 | 4980 | 3990 | 1770 |
| Spare Tray | 26.5 | 38.2 | - 7.7 | 45.3 | 1290 | 1360 | 140 |
| PSA | 56.7 | 45.0 | - 1.1 | 41.5 | 3630 | 1340 | 2410 |
| Junction Box | 12.2 | 45.2 | 0.0 | 53.1 | 550 | 50 | 540 |
| Coolant Hoses | 1.0 | | | | | | |

(continued)

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Table 2-II. Command Module center of gravity and moment of inertia data (cont'd.)

| Item | Weight (lbs) | Centers of Gravity (inches) | | | Moments of Inertia (lb-in ²) | | |
|----------------------------|--------------|-----------------------------|---|---|--|-----|-----|
| | | X | Y | Z | Ixx | Iyy | Izz |
| <u>MAIN PANEL AREA</u> | 15.0 | | | | | | |
| D & C/AGC | | | | | | | |
| <u>LOOSE STORED ITEMS</u> | | | | | | | |
| Eye Relief Eyepieces (2) | 1.5 | | | | | | |
| Film Cartridges (4) | 3.0 | | | | | | |
| AGC Loose Spares | 17.0 | | | | | | |
| PSA Loose Spares | 11.5 | | | | | | |
| CDU Spare Gearbox | 3.0 | | | | | | |
| Computer Self-Check Plugs | 1.0 | | | | | | |
| Horizon Photometer | 4.0 | | | | | | |
| Spare Lamps (3) | 0.2 | | | | | | |
| Spare Relay & Diode Module | 0.3 | | | | | | |

(SCT - 4 5/8" x 2 1/2" dia; SXT - 3" x 2 1/4" dia.)
 (Each cartridge - 1 1/2 x 3 x 6 inches)

(approximately 6.0 x 1 13/16 x 5.5 inches)
 (3 x 1 x 1 inches)
 (6 x 6 x 3 inches)
 (3 x 3 x 2 inches)

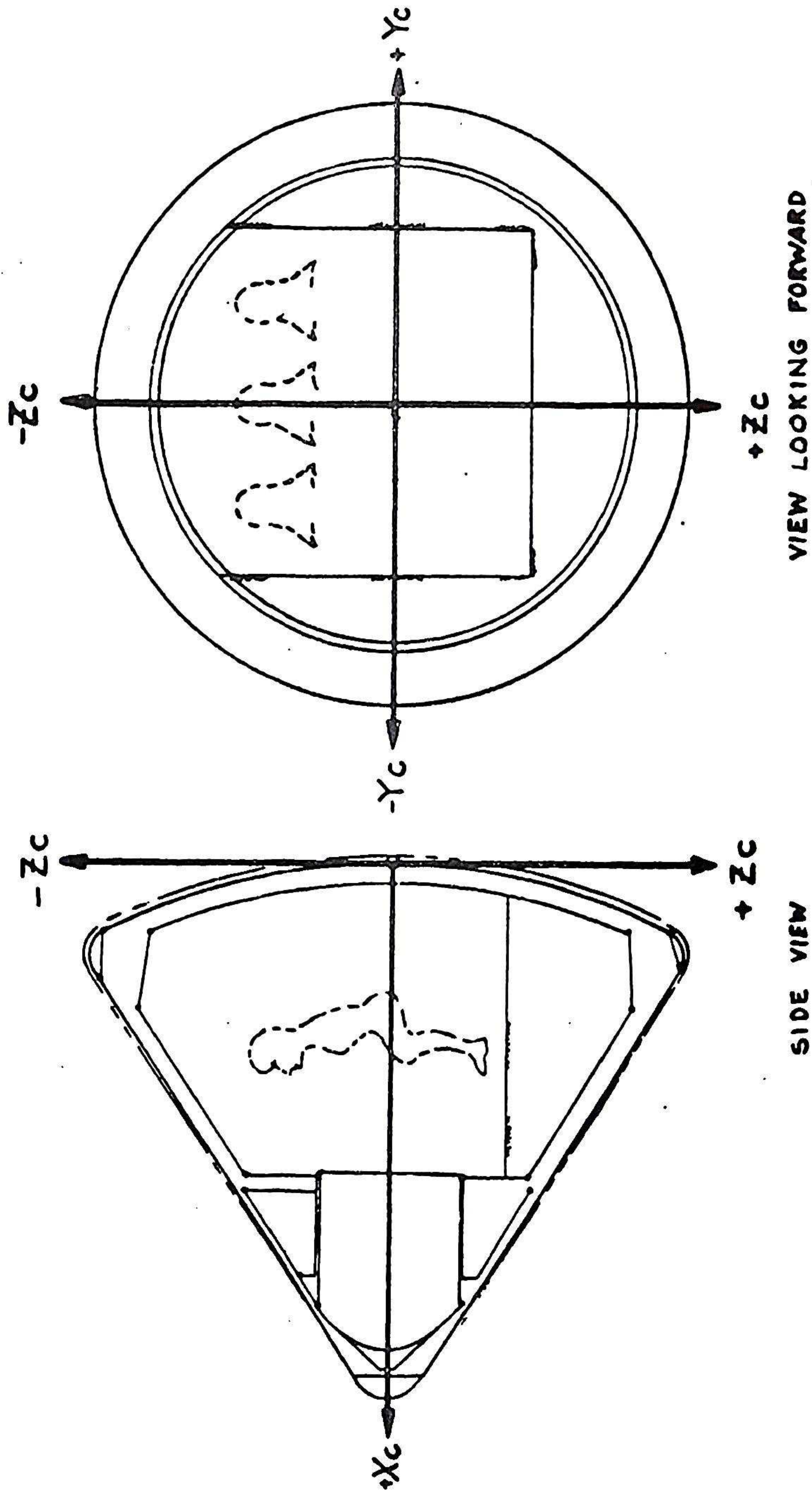


Figure 2-1. X, Y, Z axes of Command Module

Section 3

LUNAR EXCURSION MODULE WEIGHT DATA

3-1 WEIGHTS

Lunar Excursion Module weights are presented in table 3-I. The data, in general, conforms to the information contained in paragraphs 2-1 and 2-1.1.

LEM

Table 3-I. Estimated weights of LEM G&N components

| Item | Spec. Wt. (a) | (b-a) | Status 7/63 (b) | (c-b) | Status 8/63 (c) | Design Load Wt. (d) |
|--------------------------------|---------------|-------|-----------------|-------|-----------------|---------------------|
| CDU's | | | 16.0 | 0.0 | 16.0(E) | |
| Telescope and all Eyepieces | | | 12.0 | 0.0 | 12.0(E) | |
| Navigation Base | | | 4.0 | 0.0 | 4.0(E) | |
| Eye Register for Reticule | | | 2.0 | 0.0 | 2.0(E) | |
| Two Digit Readout for Reticule | | | 5.0 | 0.0 | 5.0(E) | |
| IMU | | | 58.0 | 0.0 | 58.0(E) | |
| Interconnect Harness Assy | | | 15.0 | 0.0 | 15.0(E) | |
| AGC Display and Controls | | | 15.0 | 0.0 | 15.0(E) | |
| Other Display and Controls | | | 20.0 | 0.0 | 20.0(E) | |
| Book of Procedures, etc. | | | 2.0 | 0.0 | 2.0(E) | |
| AGC, 1 Spares Tray; JBX | | | 60.0 | 0.0 | 60.0(E) | |
| PSA | | | 35.0 | 0.0 | 35.0(E) | |
| Cold Plate | | | 5.0 | 0.0 | 5.0(E) | |
| TOTAL | | | 249.0 | 0.0 | 249.0 | |

Section 4

COMMAND MODULE POWER REQUIREMENTS

4-1 POWER CHART

The power requirements of the Command Module G & N equipment, upon the primary +28 VDC Power Supply, are shown in figure 4-1, which presents the magnitude and location of dissipated power values on a sub-assembly level.

This chart assumes a 14 day lunar orbit mission.

The power chart calculations in last month's report, Weight and Balance Report (E-1142, Rev. 10), were made with the IMU on during the lunar orbit period. More reasonably, the IMU would be off during this period. This would reduce the energy requirement considerably, as is indicated in this month's power chart.

The full 14 day power profile has been determined as of August 14. This will result in several changes not shown in this month's chart, specifically, the optics operate duty cycle will reduce from 12.2% to 6.6% and the IMU operate duty cycle will increase from 14.0% to 14.4%. The total energy consumption, as a result of these changes, will reduce from 86 KWH to about 83.7 KWH.

4-2 NORMAL POWER DISSIPATION VS G & N ACTIVITY

Table 4-I shows the magnitude and location of power dissipation for various mode operation combinations.

Table 4-1 Normal power dissipation (watts) vs G & N activity

| X | G&N ACTIVITY | NBA | | CDUJB | PSA | | AGC | THERMAL LOAD ON S/C COOLANT | D&C And S&C | ELECTRICAL LOAD |
|---|---|------|------|-------|-------|--------|-----|-----------------------------------|-------------------|--------------------|
| | | IMU | OBA | | IMU | OPTICS | | | | |
| A | IMU ON WITH NO OPTICS (1, 4) | 74.5 | 0 | 22.1 | 233.5 | 0 | 120 | 450.1 | .7 | 450.8 |
| B | IMU ALIGNMENT (1, 2, 4, 6) | 74.5 | 39 | 44 | 233.5 | 63.6 | 120 | 574.6 | 32.7 | 607.3 |
| C | LOW ORBIT TRACKING (1, 3, 4, 6) | 74.5 | 33.8 | 44 | 233.5 | 59.8 | 120 | 565.6 | 32.7 | 598.3 |
| D | STANDBY (NO MEASUREMENTS) (1, 5) | 43.5 | 0 | 0 | 41.2 | 0 | 120 | 204.7 | 0 | 204.7 |
| E | MIDCOURSE MEASUREMENTS (1, 2, 5, 6) | 43.5 | 39 | 21.9 | 41.2 | 63.6 | 120 | 329.2 | 32 | 361.2 |

- 1. AGC 120 WATTS
- 2. OPTICS, SXT ON 111.1 WATTS
- 3. OPTICS, SXT OFF 102.1 WATTS
- 4. IMU OPERATE 330.8 WATTS
- 5. IMU STANDBY 84.7 WATTS
- 6. DISPLAY AND CONTROL 45.4 WATTS

Section 5

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: interconnect wiring harness which electrically ties together the assemblies which constitute a completely integrated system.

COOLANT HOSES:

Coolant Hoses: consists of (1) coolant hose between IMU and spacecraft, optics and spacecraft, and optics and IMU, (2) bracket assembly screws and clamps, and (3) coolant.

CDU & FRAME ASSEMBLY:

Coupling Display Units and frame assembly: five inter-changeable 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 panel, relays, and support structure.

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D & C/NAV: Display and Control, Navigation: consists of G&N Indicator Control Panel, IMU Control Panel, D&C Electronics, 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.

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

D & C Electronics: D & C Electronics: consists of six electronic modules in one space envelope and one step down power transformer in another envelope.

LONG EYE RELIEF EYE-PIECES: Long 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.

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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. Includes three snubbers and three bolts.

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 and internal cooling.

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.

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

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