

APOLLO

GUIDANCE AND NAVIGATION

Approved: Milton B. Trageser Date: 6/15/65
MILTON B. TRAGESER, DIRECTOR
APOLLO GUIDANCE AND NAVIGATION PROGRAM

Approved: Roger B. Woodbury Date: 6/16/65
ROGER B. WOODBURY, DEPUTY DIRECTOR
INSTRUMENTATION LABORATORY

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E-1142 (Rev 33)

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SYSTEM STATUS REPORT

June 15, 1965



INSTRUMENTATION LABORATORY

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ABSTRACT

The System Status Report is distributed monthly on the 15th. This month's revision of E-1142 (Rev. 33) contains, in general, the following 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

Based upon a Request Engineering Change Proposal (RECP) issued from NASA/ MSC dated 12 January 1965 this report incorporates Horizontal Hand Holds on the G&N Panel adjacent to the optics controller and the attitude controller for Block I (100 series) and Block II Systems for use during navigation sightings. These hand holds are a part of the body tethering system for the spacecraft and will be removed during flight and kept as a loose stored item.

At the last Status Review Meeting on May 26, 1965 held at Kollsman, MIT proposed an in-flight lens cleaning kit as a desirable loose stored item for Block I (100 series) and Block II. MSC is now presumably considering this item as part of the flight G&N equipment. RECP action has not yet been initiated.

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 Land Mission: Status of computer and reliability values.
- (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: 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.

BLOCK I
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. 32), May 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 (100 SERIES). Column (d) of Table 2-I contains the "not to exceed" design load weights for individual Block I G&N 100 series subsystems. These weights were assigned per ICD MH01-01256-416, signed June 3, 1965.

2-2 REPORTED BLOCK I 100 SERIES WEIGHT CHANGES

2-2.1 HORIZONTAL HAND HOLDS (+1.0 lb). These will be used by the astronauts during the navigation sightings. For additional information see paragraph 1-1.

2-2.2 LENS CLEANING KIT (+0.1 lb). The cleaning kit will be used during the lunar mission for cleaning the optics lens. For additional information see paragraph 1-1.

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BLOCK I
COMMAND MODULE

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

| | 100 Series Control Weight (a) | (b-a) | 100 Series Status 5/65 (b) | (c-b) | 100 Series Status 6/65 (c) | 100 Series Design Load Wt. 1/65 (d) |
|--|-------------------------------|-------|----------------------------|-------|----------------------------|-------------------------------------|
| <u>G&N SYSTEMS</u> | | | | | | |
| CDU Assy | | | 14.1 (M) | 0.0 | 14.1 (E) | 16.0 |
| Optical Subsystem | | | | | | } 155.0† |
| 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) | |
| 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) | |
| Coolant Hoses (two) | | | 0.8 (E) | 0.0 | 0.8 (E) | |
| Power Servo Assy | | | 59.8 (C) | 0.0 | 59.8 (C) | |
| G&N Interconnection Assy | | | 27.3 (E) | 0.0 | 27.3 (E) | |
| G&N to S/C Interface Assy } AGC (no spares) | | | 87.0 (M) | 0.0 | 87.0 (M) | 120.0 |
| Optical Shroud | | | 3.1 (E) | 0.0 | 3.1 (E) | 4.5 |
| <u>LOWER EQUIPMENT BAY</u> | | | | | | |
| <u>D&C</u> | | | | | | |
| D&C Electronics | | | 3.0 (E) | 0.0 | 3.0 (E) | 5.0 |
| Control Electronics | | | 2.1 (E) | 0.0 | 2.1 (E) | 4.0 |
| G&N Ind Cont Panel | | | 10.5 (E) | 0.0 | 10.5 (E) | 15.0 |
| IMU Control Panel | | | 2.8 (E) | 0.0 | 2.8 (E) | 5.0 |
| Condition Annunciator Assy | | | 1.2 (E) | 0.0 | 1.2 (E) | 2.0 |
| D&C/AGC | | | 23.0 (M) | 0.0 | 23.0 (M) | 26.0 |
| Horizon Photo. Elect. | | | 2.2 (C) | 0.0 | 2.2 (C) | 4.0 |
| Signal Conditioner Assy | | | 3.9 (C) | 0.0 | 3.9 (C) | 8.0 |
| <u>MAIN PANEL AREA</u> | | | | | | |
| D&C/AGC | | | 25.2 (E) | 0.0 | 25.2 (E) | 26.0 |

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COMMAND MODULE

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 5/65 (b) | (c-b) | 100 Series Status 6/65 (c) | 100 Series Design Load Wt. 1/65 (d) |
|---------------------------|-------------------------------|-------|----------------------------|-------|----------------------------|-------------------------------------|
| <u>LOOSE STORED ITEMS</u> | | | | | | |
| Optical Eyepieces | | | | | | |
| SXT | | | 1.6 (C) | 0.0 | 1.6 (C) | } 7.2 |
| SCT | | | 2.6 (C) | 0.0 | 2.6 (C) | |
| Eye Relief Eyepieces | | | 1.5 (E) | 0.0 | 1.5 (E) | } 2.5 |
| Optics Cover | | | 1.6 (C) | 0.0 | 1.6 (C) | |
| Horizontal Hand Holds | | | | +1.0 | 1.0 (E) | } 1.0 |
| Lens Cleaning Kit | | | | +0.1 | 0.1 (E) | |
| TOTAL | 430.0* | -7.8 | 422.2 | +1.1 | 423.3 | 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.

†This design load weight is figured to include only 1/2 the weight of the Bellows Assembly.

§Design Load Weights are taken from ICD MH01-01256 (signed June 3, 1965, submitted by MIT by letter AG-478-65).

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

At the present time since Block I (100 series) G&N equipment is not available in-house and ACSP is not contractually obligated to perform moments of inertia calculations or measurements, MIT is using Block I zero series information and final production drawings to calculate the Block I (100 series) moments of inertia and centers of gravity. These data will appear in future reports. Table 2-II summarizes Block I (300 series) data.

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

| Weight (lb) | Center of Gravity (in) | Moments of Inertia* (slug ft ²) |
|----------------|---------------------------|--|
| 408.9 | X 55.1 | Ixx 146.8 |
| | Y -0.3 | Iyy 418.1 |
| | Z 37.3 | Izz 282.1 |

*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 8.27-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 8.27-day mission submitted by the AMPTF (GAEC Report No. LED-540-12, October 30, 1964). The 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

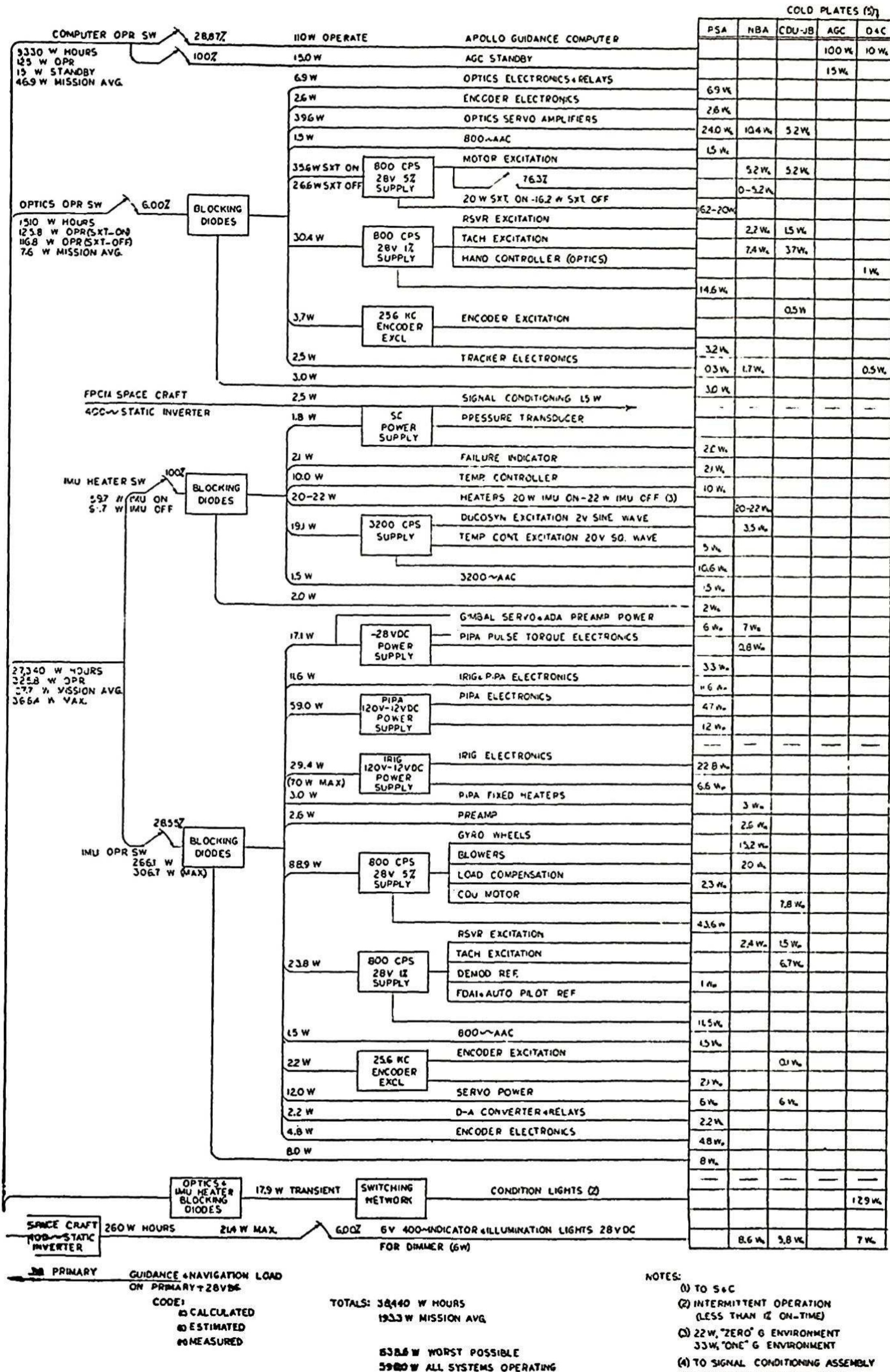


Figure 2-1. Electrical Load on Primary +28 VDC Power Supply for Block I (100 Series) Systems

BLOCK I
COMMAND MODULE

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 | | | 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 | AGC | | | | |
| 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

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Table 2-IV. Block I (100 Series) Command Module Energy Consumption Profile for 8.27-Day Lunar Orbit Mission

| M O D E | G&N Activity | Energy Consumption (kwh) | | | | | | | Total |
|------------------|--|--|--|---|--|--|--|---|--------|
| | | (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 | |
| 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 |

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2-5 STATUS OF COMMAND MODULE AGC PROGRAM

The Block I Command Module program status (Table 2-V) reflects the lunar landing mission exclusive of the stabilization and control function.

The Block II Command Module computer program, which contains S&C functions, is in the process of being calculated and will be reported when the values become established.

Table 2-V. Current Memory Capacity of Command Module
 AGC Programs (6/15/65)

| Item | Memory words |
|--|--------------|
| List Processing Interpreter | 1762 |
| AGC Executive | 318 |
| AGC Waitlister | 190 |
| AGC Self-Check | 889 |
| G&N System Test | 1699 |
| Display & Keyboard | 2847 |
| Input/Output Control | 1769 |
| Navigation | 1775 |
| Powered Flight Guidance & Attitude Control | 1052 |
| Prelaunch Alignment* | 782 |
| In-Flight Alignment* | 925 |
| Re-Entry | 1543 |
| Re-Start and First Start | 468 |
| Mission Sequencing (202) | 960 |
| Miscellaneous | 497 |
| | 17476 |

*Estimated.

BLOCK II COMMAND MODULE

Section 3

BLOCK II COMMAND MODULE DATA

3-1 RELIABILITY

The operating times and associated mission success probabilities in Table 3-I are based upon the Apollo Mission Planning Task Force (AMPTF) time line listed in GAEC Report LED-540-12, dated October 30, 1965, which uses the interval of Command Module operation from earth launch until LEM separation.

3-2 WEIGHTS FOR THE BLOCK II COMMAND MODULE

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

3-3 REPORTED BLOCK II WEIGHT CHANGES

3-3.1 IMU (-0.8 lb). The decrease is due to the measured weight of IMU (200-4) which will be used with system 600-F.

3-3.2 SIGNAL CONDITIONER ASSY (+2.6 lbs). The Signal Conditioner Assy weight has been recalculated to reflect the latest information from the circuitry groups.

3-3.3 HORIZONTAL HAND HOLDS (+1.0 lb). These will be used by the astronauts during navigation sightings. For additional information see paragraph 1-1.

3-3.4 LENS CLEANING KIT (+0.1 lb). This kit will be used during the lunar mission for cleaning the optics lens. For additional information see paragraph 1-1.

3-4 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 an 8.27-day lunar orbit 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. These values are average values (Ref: GAEC Report LED-540-12, October 30, 1964). A decrease of 536 watt-hours was reported this month due to measuring the CDU Block II & LEM breadboard power values.

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Table 3-I. Reliability Estimates For Variations of AMPTF Design Reference Mission
 (Probability of success of CSM PGNCS from earth launch until LEM separation.
 Elapsed time of approximately 68 hours.)

| PGNCS Subsystem | Operate Failure Rate Per 10 ⁶ hrs | Operate Time (hrs) | Standby Failure Rate Per 10 ⁶ hrs | Standby Time (hrs) | Failures Per 10 ⁶ Missions | Success Probability |
|--------------------|--|--------------------|--|--------------------|---------------------------------------|---------------------|
| IMU | 129 | 12.5 | 7.8 | 55.6 | 2046 | 0.99796 |
| IMU Electronics | 110 | 12.5 | 6.3 | 55.6 | 1725 | 0.99827 |
| CDU (IMU) | 171 | 12.5 | 0 | 55.6 | 2138 | 0.99797 |
| Optics | 94 | 7.8 | 0 | 59.1 | 733 | 0.9993 |
| Optics Electronics | 77 | 7.8 | 0 | 59.1 | 601 | 0.9994 |
| CDU (Optics) | 114 | 7.8 | 0 | 59.1 | 889 | 0.9992 |
| AGC | 357 | 12.5 | 96.4 | 55.6 | 9822 | 0.991 |
| DSKY (2) | 117/12.5 hrs | 12.5 | 0 | 55.6 | 117 | 0.99999* |
| D&C | 13 | 12.5 | 0 | 55.6 | 163 | 0.99994 |
| Total | | | | | 18234 | 0.982 |

*Success requires that only one of redundant pair of DSKY's not fail.

BLOCK II
COMMAND MODULE

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 activities (phases of operation) for the model 8.27-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.

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BLOCK II
COMMAND MODULE

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

| Item | Control Weight (a) | (b-a) | Status 5/65 (b) | (c-b) | Status 6/65 (c) | Design Load Wt. 5/64 (d) |
|----------------------------|--------------------|-------|-----------------|-------|-----------------|--------------------------|
| <u>G&N SYSTEMS</u> | | | | | | |
| 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 | | | 4.4 (E) | 0.0 | 4.4 (E) | |
| SCT | | | 4.7 (E) | 0.0 | 4.7 (E) | |
| NVB & Mounts | | | 14.9 (E) | 0.0 | 14.9 (E) | |
| Bellows Assy | | | 12.7 (E) | 0.0 | 12.7 (E) | |
| IMU | | | 42.1 (E) | -0.8 | 41.3 (M) | |
| Coolant Hoses (two) | | | 0.8 (E) | 0.0 | 0.8 (E) | |
| Power Servo Assy† | | | 41.5 (E) | 0.0 | 41.5 (E) | |
| PIPA Electronics Assy | | | 7.9 (E) | 0.0 | 7.9 (E) | |
| Interconnect Harness Assy | | | 30.0 (E) | 0.0 | 30.0 (E) | |
| AGC | | | 58.0 (E) | 0.0 | 58.0 (E) | |
| Optical Shroud | | | 3.1 (E) | 0.0 | 3.1 (E) | |
| <u>LOWER EQUIPMENT BAY</u> | | | | | | |
| <u>D&C</u> | | | | | | |
| G&N Ind Cont Panel | | | 12.1 (E) | 0.0 | 12.1 (E) | |
| D&C/AGC | | | 17.5 (E) | 0.0 | 17.5 (E) | |
| Signal Conditioner Assy | | | 3.9 (C) | +2.6 | 6.5 (C) | |
| <u>MAIN PANEL AREA</u> | | | | | | |
| D&C/AGC | | | 17.5 (E) | 0.0 | 17.5 (E) | |

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

| Item | Control Weight (a) | (b-a) | Status 5/65 (b) | (c-b) | Status 6/65 (c) | Design Load Wt. 5/64 (d) |
|---|--------------------|-------|-----------------|---------------------|-------------------------------|--------------------------|
| <u>LOOSE STORED ITEMS</u> Optics Cover Horizontal Hand Holds Lens Cleaning Kit | | | 1.6 (E) | 0.0 +1.0 +0.1 | 1.6 (E) 1.0 (E) 0.1 (E) | |
| Total | 400.0 § | -44.3 | 355.7 | +1.8 | 357.5 | 492.6** |

*The eyepiece weights quoted here are for the full magnification 2.2-inch eye-relief eyepieces designed by MIT under NASA direction. At this time MIT is awaiting NASA instructions as to which of the two possible eyepiece designs to use in the Block II G&N.

† Includes the weight of the PSA Cover.

§ Total Control Weight specified in letter EG-151-44 (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 2-32 (February 11, 1964). It does not include loose stored items.

BLOCK II COMMAND MODULE

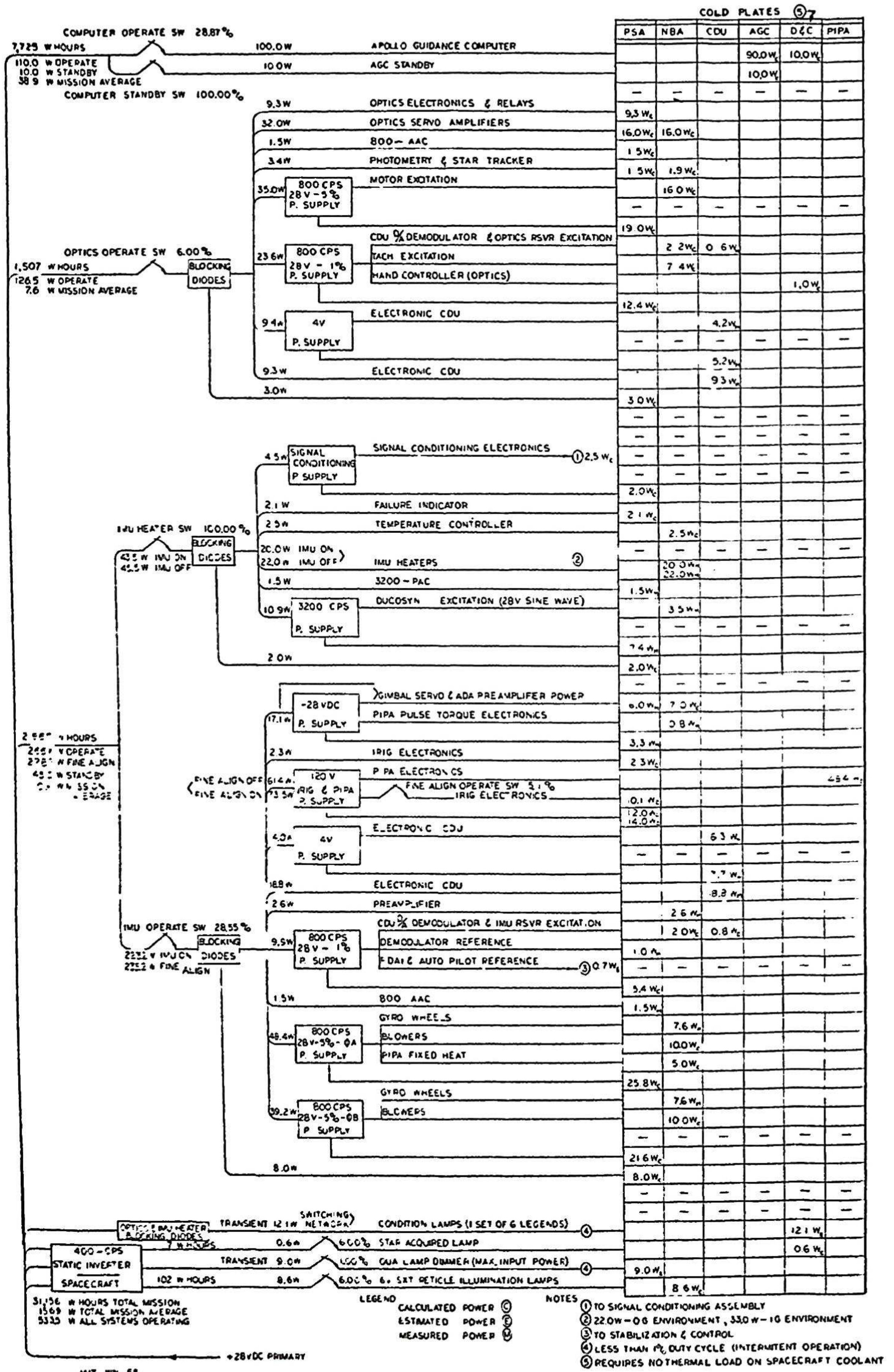


Figure 3-1. Electrical Load on Primary +28 VDC Power Supply

BLOCK II

COMMAND MODULE

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 | 32.8 | 0.0 | 154.3 | 0.0 | 100.0 | 365.7 | 10.7 | 376.7 |
| B | IMU Alignments Sextant Sightings (Midcourse Navigation) Landmark Tracking (Low-orbit Navigation) (1, 3, 4, 6) | 78.6 | 32.8 | 44.9 | 18.7 | 154.3 | 62.7 | 100.0 | 491.5 | 33.8 | 525.3 |
| 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 | 18.7 | 18.0 | 62.7 | 100.0 | 271.5 | 33.1 | 304.6 |
| 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 126.5 watts
4. IMU Operate 266.7 watts
5. IMU Standby 46.0 watts
6. D&C Operate 22.1 watts

BLOCK II
COMMAND MODULE

Table 3-IV. Block II Command Module Energy Consumption Profile for 8.27-Day Lunar Orbit Mission

| M O D E | G&N Activity | Energy Consumption (kwh) | | | | | | Total |
|------------------|---|--|--|---|--|--|---|--------|
| | | (1) AGC Operate 110.0 watts 57.38 hours | (2) AGC Standby 10.0 watts 141.31 hours | (3) Optics Operate 126.5 watts 11.91 hours | (4) IMU Operate 266.7 watts 56.73 hours | (5) IMU Standby 46.0 watts 141.96 hours | (6) D&C Operate 22.1 watts 11.91 hours | |
| A | Accomplish & Confirm Course Corrections Major Maneuvers Inactivity & Monitor 376.7 watts 45.12 hours | 4.963 | - | - | 12.034 | - | - | 16.997 |
| B | IMU Alignments Sextants Sightings (Midcourse Navigation) Landmark Trackings (Low-orbit Navigation) 525.3 watts 11.61 hours | 1.277 | - | 1.469 | 3.096 | - | 0.257 | 6.099 |
| C | Inactivity & Monitor 156.0 watts 0.35 hours | 0.039 | - | - | - | 0.016 | - | 0.055 |
| D | Sextant Sightings (Midcourse Navigation) 304.6 watts 0.30 hours | 0.033 | - | 0.038 | - | 0.014 | 0.007 | 0.092 |
| E | Inactivity & Monitor 56.0 watts 141.31 hours | - | 1.413 | - | - | 6.500 | - | 7.913 |
| | Total 198.55 hours | 6.312 | 1.413 | 1.507 | 15.130 | 6.530 | 0.264 | 31.156 |

LUNAR EXCURSION MODULE

Section 4

LUNAR EXCURSION MODULE DATA

4-1 RELIABILITY

The operating times and associated mission success probabilities in Table 4-I are based upon the Apollo Mission Planning Task Force (AMPTF) time line listed in GAEC Report No. LED-540-12, dated 30 October 1964, which uses the interval of LEM operation from earth launch to lunar touchdown.

4-2 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.

4-3 REPORTED LEM WEIGHT CHANGES

4-3.1 IMU (-0.8 lb). The decrease is due to the measured weight of IMU (200-4) which will be used with systems 600-F.

4-4 POWER REQUIREMENTS

The estimate for LEM power and energy consumption shown in figure 4-1 is based upon the 8.27-day lunar orbit mission as defined by the Apollo Mission Planning Task Force (AMPTF) for power profile computation (Ref: GAEC Report LED-540-12, dated October 30, 1964). A decrease of 115 watt-hours was reported this month due to measuring the CDU Block II & LEM breadboard power values.

Table 4-III shows the energy requirements for each G&N activity on a power level basis. The table is also based upon GAEC Report LED-540-12. 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.

CONFIDENTIAL
LUNAR EXCURSION MODULE

Table 4-I. Reliability Estimate for LEM G&N Based on AMPTF Design Reference Mission
(Probabilities for LEM PGNCS from earth launch until LEM touchdown.)

| PGNCS Subsystem | Operate Failure Rate Per 10 ⁶ hrs | Operate Time (hrs) | Standby Failure Rate Per 10 ⁶ hrs | Standby Time (hrs) | Failures Per 10 ⁶ Missions | Success Probability |
|--------------------|--|--------------------|--|--------------------|---------------------------------------|---------------------|
| IMU | 129 | 3.25 | 7.8 | 66.2 | 936 | 0.9991 |
| IMU Electronics | 105 | 3.25 | 6.3 | 66.2 | 758 | 0.9993 |
| CDU (IMU) | 183 | 3.25 | 0 | 0 | 595 | 0.9995 |
| Optics | 38 | 3.25 | 0 | 0 | 124 | 0.99988 |
| Optics Electronics | 38 | 3.25 | 0 | 0 | 124 | 0.99988 |
| CDU (Optics) | 122 | 3.25 | 0 | 0 | 397 | 0.9997 |
| AGC | 357 | 3.25 | 0 | 0 | 1160 | 0.9989 |
| DSKY | 293 | 3.25 | 0 | 0 | 952 | 0.9991 |
| D&C | 13 | 3.25 | 0 | 0 | 42 | 0.99996 |
| Total | | | | | 5088 | 0.995 |

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LUNAR EXCURSION MODULE

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

| Item | Control Weight (a) | (b-a) | Status 5/65 (b) | (c-b) | Status 6/65 (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) | |
| IMU | | | 42.1 (E) | -0.8 | 41.3 (M) | |
| 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) | |
| Signal Conditioner Assy | | | 6.2 (E) | 0.0 | 6.2 (E) | |
| Total | 240.0† | -12.5 | 227.5 | -0.8 | 226.7 | |
| Bare Guidance System (IMU, PSA, PTA & LGC) | | | 127.3 | -0.8 | 126.5 | |

*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.

LUNAR EXCURSION MODULE

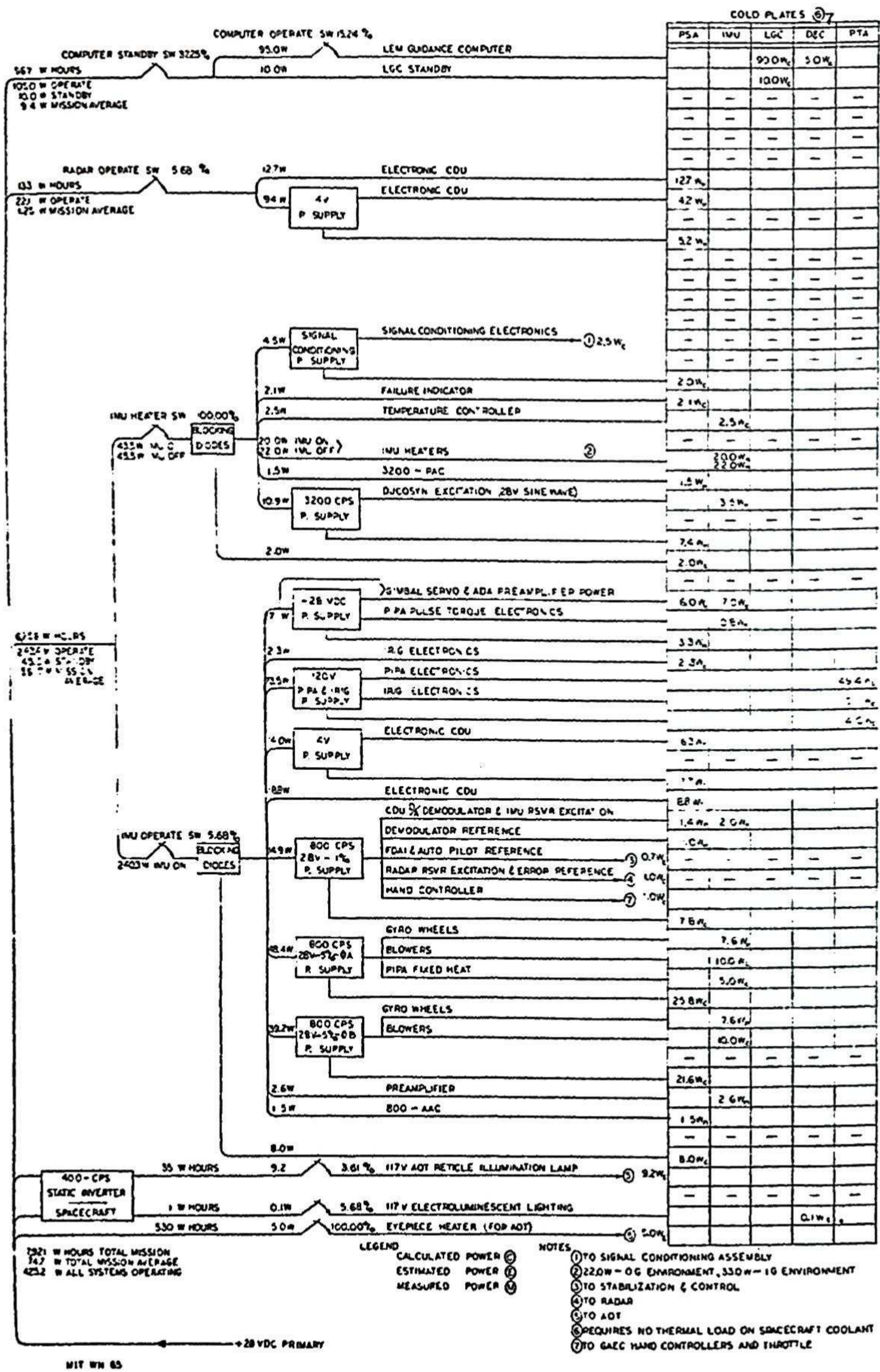


Figure 4-1. Electrical Load on Primary +28 VDC Power Supply

LUNAR EXCURSION MODULE

Table 4-III. Lunar Excursion Module Power Profile Based on GAEC Report LED-540-12

| M O D E | Activity | Energy Consumption (kwh) | | | | | | | | Total |
|------------------|--|--|---|---|---|---|---|--|--|-------|
| | | (1) LGC Off 0 watts 66.52 hours | (2) LGC Operate 105 watts 6.02 hours | (3) LGC Standby 10 watts 33.48 hours | (4) IMU Operate 283.8 watts 6.02 hours | (5) IMU Standby 45.5 watts 100 hours | (6) Two Radar CDU Operate 22.1 watts 6.02 hours | (7) OMU (AOT) Operate 9.2 watts 3.83 hours | (8) AOT Eyepiece heater 5 watts 106.02 hours | |
| I | Inactivity 50.5 watts 66.52 hours | 0.000 | - | - | - | 3.027 | - | - | 0.333 | 3.360 |
| II | Inactivity Alignment Midcourse Measurements 425.1 watts 3.83 hours | - | 0.402 | - | 1.084 | - | 0.085 | 0.035 | 0.019 | 1.625 |
| III | Guidance During Major Event 415.9 watts 2.19 hours | - | 0.230 | - | 0.622 | - | 0.048 | - | 0.011 | 0.911 |
| IV | Inactivity 60.5 watts 33.48 hours | - | - | 0.335 | - | 1.523 | - | - | 0.167 | 2.025 |
| | Total 106.02 hours | 0.000 | 0.632 | 0.335 | 1.706 | 4.550 | 0.133 | 0.035 | 0.530 | 7.921 |

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.

Condition Annunciator Assembly

CM BLOCK I Visually displays G&N system malfunctions. This function was previously part of the Map & Data Viewer.

CM BLOCK II AND LEM Not defined as yet for Block II and LEM.

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 in the lower equipment bay.

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

LEM Not required.

Horizontal Hand Holds

CM BLOCK I AND CM BLOCK II Hand holds on the G&N Panel for use during navigation sightings. These Hand Holds are a part of the body tethering system for the S/C and will be removed during flight.

LEM Not defined in LEM.

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.

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.

Lens Cleaning Kit

CM BLOCK I AND CM BLOCK II Not specially defined but appropriate cloths for cleaning the accessible surfaces of the optics lens.

LEM Not defined in LEM.

Long-Eye-Relief Eyepieces

CM BLOCK I 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.

CM BLOCK II Combination eyepiece, regular and long-eye-relief, that has full power and full field of view.

LEM Long-eye-relief eyepieces are 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 A polyurethane filled aluminum skinned structure functionally similar to Block I but lighter and will 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 re-orientation 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 Removable SXT eyepiece and SCT eyepiece.

CM BLOCK II Combination eyepiece, regular and long-eye-relief, that has full power and full field of view.

LEM Included as part of the AOT.

Optical Subsystem

CM BLOCK I AND CM 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 lower equipment bay DSKY.

LEM Same as for Block I.

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USAF Contract Management District
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