

~~CONFIDENTIAL~~

COPY # 4 OF 91 COPIES  
THIS DOCUMENT CONTAINS 52 PAGES

Approved: Milton B. Trageser Date: 12/21/65  
MILTON B. TRAGESER, DIRECTOR  
APOLLO GUIDANCE AND NAVIGATION PROGRAM

Approved: Roger B. Woodbury Date: 12/27/65  
ROGER B. WOODBURY, DEPUTY DIRECTOR  
INSTRUMENTATION LABORATORY

This document contains information affecting the National Defense of the United States within the meaning of the Espionage Laws (Title 18, Sections 793 and 794) its transmission or revelation of its contents in any manner to an unauthorized person is prohibited by Law.

E-1142 (Rev. 39)

(Unclassified Title)

SYSTEM STATUS REPORT

December 1965

DECLASSIFIED AT 3 YEAR INTERVALS  
DECLASSIFIED AFTER 12 YEARS  
DOD DIR 5200.10

Reclassified to Unclassified  
by authority of SP-6 [Signature]  
22a, SA - SEP 7 1970  
Miss [Signature] - 74, 71

~~CONFIDENTIAL~~

UNCLASSIFIED

ACKNOWLEDGEMENT

This report was prepared under DSR Project 55-238, sponsored by the Manned Spacecraft Center of the National Aeronautics and Space Administration through Contract NAS 9-4065.

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.

The publication of this report does not constitute approval by the National Aeronautics and Space Administration of the findings or the conclusions contained therein. It is published only for the exchange and stimulation of ideas.

UNCLASSIFIED

UNCLASSIFIED

E-1142

SYSTEM STATUS REPORT  
(Unclassified Title)

ABSTRACT  
(Unclassified)

The System Status Report is distributed on the 15th of each month. The areas of activity reported on in this month's revision include, but are not limited to, the following for the Block I 100 Series and Block II Command Modules and Lunar Excursion Module equipment: configuration weight, weight trend information, centers of gravity, moments of inertia, electrical power requirements, computer programming status, and reliability estimates.

by Apollo Staff  
December 15, 1965

UNCLASSIFIED

# UNCLASSIFIED

## TABLE OF CONTENTS

	<u>Page</u>
Accuracy	7
Introduction	9
<u>Section</u>	
1 Weights	10
Reported Block I 100 Series G&N Weight Changes	14
Reported Block II GN & C Weight Changes	17
Block II Weight Reduction Proposals	18
Reported LEM GN & C Weight Changes	20
LEM Weight Reduction Proposals	21
2 Centers of Gravity and Moments of Inertia	23
Summary of Weight and Balance Data Block I Zero Series	24
3 Glossary and System Definition	25
Command Module Block I	26
Command Module Block II	32
Lunar Excursion Module	38
4 Reliability	43
5 Guidance Computer Programming	47
Flight 202	48
Block II & LEM	48
6 Electrical Power and Energy	51

UNCLASSIFIED

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.

UNCLASSIFIED

# UNCLASSIFIED

## INTRODUCTION

The areas of activity reported on in this month's revision include, in general, the following for the Block I 100 Series and Block II Command Modules and Lunar Excursion Module equipment:

Section 1 - Configuration Weight  
Weight Changes  
Weight Trend Information

Section 2 - Centers of Gravity  
Moments of Inertia

Section 3 - Glossary and System Definition

Section 4 - Reliability Estimates

Section 5 - Computer Programming Status

Section 6 - Electrical Power Requirements

Additional material, not suited to this format, will be presented from time to time as an appendix when it is particularly significant.

# UNCLASSIFIED

## SECTION 1

### WEIGHTS

Weights are reported to the nearest tenth of a pound on a component level. Each component weight is identified as estimated, calculated, or measured in order of increasing accuracy. These terms are defined 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.

Tables 1, 2, and 3, respectively, present the weight of all CM Block I 100 Series, CM Block II, and LEM Guidance and Navigation equipment based upon the most current information. These tables offer a comparison of present component weight values with those listed in last month's revision of the System Status Report.

Also included are the respective control and design load weights as assigned by NASA. The Control Weight is the maximum allowable total weight of the Apollo Guidance and Navigation equipment for which MIT/IL is responsible. Design Load Weights are restricted to individual components and should be considered as "not to exceed" weights. These values represent a maximum within which design variations may cause changes without need for renegotiation.

The row labeled "Bare Guidance System" is inserted to provide for comparisons with similarly specified systems.

North American Aviation and Grumman Aircraft Engineering Corporation will provide and be responsible for weights of cold plates that are not integral with guidance and control equipment.

# UNCLASSIFIED

After each table is an explanation of all weight changes reported this month with each component weight increment or decrement. A discussion of future weight changes of components presently being studied will also be reported.

Special attention should be paid to the weight reduction proposals.



TABLE 1. CURRENT WEIGHT STATUS OF BLOCK I 100 SERIES  
COMMAND MODULE PGNS (LBS AT IG)

Command Module G&N Equipment	Status 11/65	Change	Status 12/65	Design Load Wt.* 7/65
<u>LOWER EQUIPMENT BAY</u>				
CDU Assy	14.1 (M)	0.0	14.1 (M)	16.0
Optical Subsystem				
SXT	47.6 (M)	0.0	47.6 (M)	155.0**
SCT	25.7 (M)	0.0	25.7 (M)	
Optical Base and Gearing	12.7 (M)	0.0	12.7 (M)	
NVB and Resilient Mounts	61.2 (M)	0.0	61.2 (M)	
Bellows Assy	0.9 (M)	0.0	0.9 (M)	
IMU	65.4 (M)	0.0	65.4 (M)	
Coolant Hoses (two)	26.1 (M)	0.0	26.1 (M)	120.0
Power Servo Assy	3.1 (M)	0.0	3.1 (M)	4.5
G&N Interconnection Assy	87.0 (E)	0.0	87.0 (E)	100.0
Optical Shroud	5.0 (E)	0.0	5.0 (E)	--
G&N to S/C Interface Assy	2.0 (E)	0.0	2.0 (E)	2.0
AGC	1.5 (M)	0.0	1.5 (M)	7.2
Optical Eyepiece Storage Assy	2.8 (M)	0.0	2.8 (M)	
Condition Annunciator Assy	0.8 (M)	0.0	0.8 (M)	
SXT Eyepiece	2.6 (M)	0.0	2.6 (M)	5.0
SCT Eyepiece	1.8 (M)	0.0	1.8 (M)	4.0
SCT Long Eye Relief Eyepiece				
D&C Electronics Assy				
Control Electronics Assy				

\*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) its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by Law.

TABLE 1. CURRENT WEIGHT STATUS OF BLOCK I 100 SERIES  
COMMAND MODULE PGNS (LBS AT IG) (CONT)

Command Module G&N Equipment	Status 1 1/65	Change	Status 12/65	Design * Load Wt. 7/65
G&N Indicator Control Panel	10.9 (M)	0.0	10.9 (M)	15.0
IMU Control Panel	2.9 (M)	0.0	2.9 (M)	5.0
Horizon Photometer Electronics	2.2 (C)	-2.2	0.0 (M)	4.0
Signal Conditioner Assy	3.9 (C)	0.0	3.9 (C)	8.0
D&C/AGC	23.0 (M)	0.0	23.0 (M)	26.0
<u>MAIN PANEL AREA</u>				
D&C/AGC	25.2 (E)	0.0	25.2 (E)	26.0
<u>LOOSE STORED ITEMS</u>				
Optics Cover	2.1 (M)	0.0	2.1 (M)	2.5
Horizontal Hand Holds (Two)	1.0 (E)	0.0	1.0 (E)	1.0
<b>TOTAL</b>	<b>431.5</b>	<b>-2.2</b>	<b>429.3</b>	<b>--</b>
The reported total weight for this month is 0.7 pounds less than the 430.0 pounds total control weight†				
Bare Guidance Systems - IMU, AGC, IMU portions of the CDU's and IMU Support electronics			200.6	-- --
* Design Load Weights are taken from ICD MH01-01256-416 (signed June 3, 1965 submitted by MIT in letter AG 478-65).				
** This Design Load Weight includes only 1/2 the weight of the Bellows Assembly				
† 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. This weight assignment does not include recognition of the Optical Eyepiece Storage Assembly.				

UNCLASSIFIED

Reported Block I 100 Series G&N Weight Changes

Horizon Photometer Electronics (-2.2 lb)

MIT received a NASA TWX, EG 44-438-65-693 dated 29 September 1965, deleting the Star Tracker - Horizon Photometer from Block I 100 Series systems. In compliance MIT no longer identifies the additional electronics package mentioned above. The PSA does not reflect a similar reduction in weight because dummy modules will be used in lieu of operational modules.

UNCLASSIFIED

DOWNGRADED AT 3 YEAR INTERVALS  
DECLASSIFIED AFTER 12 YEARS

DOD DIR 5200.10

"This document contains information affecting the National Defense of the United States within the meaning of the Espionage Laws (Title 18, U.S.C., Sec. 793 and 794) the transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by Law."

CONFIDENTIAL

TABLE 2. CURRENT WEIGHT STATUS OF BLOCK II COMMAND MODULE PGNC'S (LBS AT IG)

Command Module GN&C Equipment	Status 1 1/65	Change	Status 12/65	Design * Load Wt. 7/65
<u>LOWER EQUIPMENT BAY</u>				
CDU Assy	35.7 (E)	0.0	35.7 (E) #	50.0
Optical Subsystem SXT SCT	47.6 (M)	0.0	47.6 (M)	
Optical Base & Gearing				150.0
NVB & Mounts	14.9 (E)	0.0	14.9 (E)	
Bellows Assy	12.7 (E)	0.0	12.7 (E)	
IMU	41.3 (M)	+0.9	42.2 (M)	
Coolant Hoses (two)	0.9 (E)	0.0	0.9 (E)	
Power Servo Assy	49.4 (E)	+0.6	50.0 (E)	58.0
PIPA Electronics Assy	9.0 (E)	0.0	9.0 (E)	12.0
G&N Interconnect Harness Assy	30.0 (E)	0.0	30.0 (E)	40.0
AGC	65.0 (E)	0.0	65.0 (E)	80.0
Optical Shroud	3.1 (M)	0.0	3.1 (M)	4.5
Optical Eyepiece Storage Assy	5.0 (E)	0.0	5.0 (E)	---
SXT Eyepiece	1.5 (M)	0.0	1.5 (M)	
SCT Eyepiece	2.8 (M)	0.0	2.8 (M)	
SCT Long Eye Relief Eyepiece	0.8 (M)	0.0	0.8 (M)	7.0
G&N Indicator Control Panel	12.1 (E)	0.0	12.1 (E)	2.0
D&C/AGC	17.5 (E)	0.0	17.5 (E)	17.0
Signal Conditioner Assy (For Operational Flights)	6.5 (E)	+1.5	8.0 (E)**	25.0
				8.0

CONFIDENTIAL

TABLE 2. CURRENT WEIGHT STATUS OF BLOCK II COMMAND MODULE PGNCS (LBS AT IG)(CONT)

Command Module GN&C Equipment	Status 11/65	Change	Status 12/65	Design * Load Wt. 7/65
<u>MAIN PANEL AREA</u>				
D&C/AGC	17.5 (E)	0.0	17.5 (E)	25.0
<u>LOOSE STORED ITEMS</u>				
Horizontal Hand Holds (two)	1.0 (E)	0.0	1.0 (E)	1.0
<b>TOTAL</b>	<b>374.3</b>	<b>+3.0</b>	<b>377.0</b>	<b>---</b>
The reported total weight for this month is 23.0 pounds less than the 400.0 pounds total control weight.†				
Bare Guidance Systems - IMU, AGC, IMU portions of the CDUs and IMU support electronics				
<p>* Design Load Weights are taken from ICD MH01-01356-416 (signed 16 July 1965, at Meeting #22A).</p> <p>† Total Control Weight specified in letter EG-151-44-65-55 (10 February 1965) from Mr. R. W. Young, ASPO, to Mr. M. Trageser, MIT/IL. This weight assignment does not include recognition of the Optical Eyepiece Storage Assembly.</p> <p>** The weight of the SCA is 9.6 (E) for R&amp;D flights; a lower value of 8.0 (E) may be expected for operational flights. See Block II GN&amp;C Weight Changes.</p> <p># See section entitled Block II Weight Reduction Proposals CDU Assy.</p>				

CLASSIFIED AFTER 12 YEARS

DOD DIR 5200.10

This document contains information affecting the National Defense of the United States within the meaning of the Espionage Laws, Title 18, U.S.C., Sec. 793 and 794, and the transmission or revelation of its contents in any manner to an unauthorized person is prohibited by Law.

## Reported Block II GN&amp;C Weight Changes

## IMU (+0.9 lb)

The measured value previously recorded is the weight of a "dry" IMU. The increase in weight is due to the addition of (1) 0.30 lb - the weight of an appropriate volume of entrapped coolant and (2) 0.55 lb - the weight of the heat exchanger insulation. The value recorded this month is the measured weight of a "wet" IMU.

## Signal Conditioning Assembly (+1.5 lb)

The weight reported is a re-estimate of the operational telemetry modules mounted in a pressurized container occupying the same volume as the Block I DSKY. The weight increase is partially a result of the effect of real circuitry rather than estimates on a signal count basis and partially because of environmental protection considerations of the packaging.

## Power Servo Assembly (+0.6 lb)

The weight of the mounting bosses for the signal conditioning assy have been added to the weight of the PSA cover. The bosses previously were included with the SCA weight estimate.

UNCLASSIFIED

## Block II Weight Reduction Proposals

### CDU Assembly

MIT is investigating a low risk approach toward effecting a major weight reduction of the Block II and LEM CDU assembly. The weight reduction will be based upon the introduction of an integrated circuit amplifier, field effect switch transistors and the use of multilayer boards. The integrated circuits and field effect switches would replace discrete component amplifiers and AC computer switches in the analog modules. This approach minimizes circuit redesign since it is based upon a component replacement concept and allows for early design release. No conceptual or functional changes in the CDU operation or mounting configuration will be effected. Repackaging of the CDU on a single tray would be accomplished with an attendant conservatively estimated weight reduction of 11 pounds. A proposal is being prepared and will be transmitted shortly to NASA.

### Signal Conditioning Assembly

A weight reduction program in this area is now under study to further miniaturize the circuits and take a less conservative environmental protection. It is estimated that the latter consideration can remove about 1.3 pounds by using potting for moisture protection rather than the present pressurized container reported herein.

UNCLASSIFIED

This document contains information concerning the National Defense of the United States within the meaning of the Espionage Laws, Title 18, U.S.C., Sections 793 and 794, and the transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by Law.

DOWNGRADED AT 3 YEAR INTERVALS  
DECLASSIFIED AFTER 12 YEARS  
DDC DIR 5200.10

CONFIDENTIAL

TABLE 3. CURRENT WEIGHT STATUS OF LEM PGNCS (LBS AT IG)

LEM GN&C Equipment	Status 11/65	Change	Status 12/65	Design Load Wt. * 11/65
IMU	41.3 (M)	+0.8	42.1 (M)	43
Navigation Base	4.0 (E)	0.0	4.0 (E)	8
AOT	23.1 (E)]	0.0	23.1 (E)	25
Button Box	2.0 (E)	0.0	2.0 (E)	2
PTA	14.8 (E)	0.0	14.8 (E)	17
Harness "B"	4.5 (E)	0.0	4.5 (E)	8
DSKY	17.5 (E)	0.0	17.5 (E)	20
LGC	65.0 (E)	0.0	65.0 (E)	65
CDU	36.8 (E)	0.0	36.8 (E) #	37
PSA	20.1 (E)	0.0	20.1 (E) **	21
Signal Conditioner Assy (For Operational Flights)	6.1 (E)	+1.6	7.7 (E)	7.2
Harness "A"	14.6 (E)	0.0	14.6 (E)	22
Lens Cleaning Kit	0.3 (E)	0.0	0.3 (E)	0.5
TOTAL	250.1	+2.4	252.5	---
The reported total weight for this month exceeds the 240.0 pounds total control weight by 12.5lbs.†				
Bare Guidance Systems - IMU, LGC, IMU portions of the CDUs and IMU support electronics				
* Design Load Weights based upon ICD LIS-490-10001 as modified by NASA letter EG-43-422-65-766 dated 27 October 1965.				
** The weight of the signal conditioner assy is 9.7 (E) for R&D flights; however, a low of 7.7 (E) may be reported for operational flights only. See LEM Weight Reduction Proposals - SCA Assy.				
† Total Control Weight specified in letter EG-151-44-65-55 (10 February 1965) from Mr. R. W. Young, ASPO, to Mr. M. Trageser, MIT/IL.				
# See section entitled LEM Weight Reduction Proposals - CDU assembly.				

CONFIDENTIAL



# UNCLASSIFIED

## Reported LEM GN&C Weight Changes

### IMU (+0.8 lb)

The measured value previously recorded is the weight of a "dry" IMU. The weight increase reflects the addition of (1) 0.27 lb - the weight of an appropriate volume of entrapped coolant and (2) 0.55 lb for the heat exchanger insulation. The figure recorded this month is the measured weight of a "wet" IMU.

### Signal Conditioning Assembly (+1.6 lb)

The weight reported is a re-estimate of the operational telemetry for a piggyback mounting in a pressurized container on top of the PSA. The weight increase is a result of partially the effect of real circuitry rather than estimates on a signal count basis and partially because of environmental protection considerations of the packaging.

UNCLASSIFIED

## LEM Weight Reduction Proposals

### CDU Assy

MIT is investigating a low risk approach toward effecting a major weight reduction of the Block II and LEM CDU assembly. The weight reduction will be based upon the introduction of an integrated circuit amplifier, field effect switch transistors and the use of multilayer boards. The integrated circuits and field effect switches would replace discrete component amplifiers and AC computer switches in the analog modules. This approach minimizes circuit redesign since it is based upon a component replacement concept and allows for early design release. No conceptual or functional changes in the CDU operation or mounting configuration will be effected. Repackaging of the CDU on a single tray would be accomplished with an attendant conservatively estimated weight reduction of 11 pounds. A proposal is being prepared and will be transmitted shortly to NASA.

### Signal Conditioning Assy

A weight reduction program in this area is now under study to further miniaturize the circuits and to take a less conservative environmental protection. It is estimated, for instance, that the latter consideration can remove about 1.2 pounds by going to potting protection from moisture rather than the present pressure container reported herein. An alternate proposal for signal conditioning weight reduction was presented to NASA at the PGNCS Critical Design Review on 2 Dec. This showed a significant weight reduction (1.65 lb down from the reported weight) could be achieved by redesigning the PSA to include the operational telemetry signal conditioning. Additional saving in harness would also result. This was processed in RID # 14 of the CDR for continuing design and ECP action.

UNCLASSIFIED

UNCLASSIFIED

Other Electronics Weight Reductions

Design studies are underway to reduce the weight of the PSA, CDU, LGC, and PTA by removing the pressurized container environmental protection and changing to potting and light covers. The results of this activity will be reported as soon as definitive results are available.

UNCLASSIFIED

UNCLASSIFIED

SECTION 2

CENTERS OF GRAVITY AND MOMENTS OF INERTIA

This information will be summarized in the near future in tabular form. These figures when reported will reflect a 10 to 20 percent accuracy. Analytical values which have been computed will be verified by experiment (Tri-Filar Pendulum Moment of Inertia Test) when actual hardware is available.

Block I Zero Series information and final production drawings are being used to calculate the Block I 100 Series moments of inertia and centers of gravity. Block II and LEM Hardware will also be reported on an item by item basis.

UNCLASSIFIED

UNCLASSIFIED

Summary of Weight and Balance Data Block I Zero Series

Weight (lb)	Center of Gravity (in)	Moments of Inertia* (slug ft <sup>2</sup> )
408.9	X 55.1 Y -0.3 Z 37.3	I <sub>xx</sub> 146.8 I <sub>yy</sub> 418.1 I <sub>zz</sub> 282.1

\*Values determined with respect to the basic X, Y, Z axes of the Command Module.

UNCLASSIFIED

UNCLASSIFIED

SECTION 3

GLOSSARY AND SYSTEM DEFINITION

A description of what constitutes MIT supplied hardware for the guidance and navigation equipment in Block I (100 Series) and Block II Command Modules and Lunar Excursion Module is contained in this section.

UNCLASSIFIED

UNCLASSIFIED

COMMAND MODULE BLOCK I

Apollo Guidance Computer (AGC)

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.

Bellows Assembly

Consists of two flexible metal bellows forming a pressure seal between CM and optical subsystem for penetration of hull.

Condition Annunciator Assembly

Visually displays G&N system status. This function was previously part of the Map & Data Viewer. The current proposal includes this in the optics eyepiece storage unit.

Coupling Data Unit (CDU) Assembly

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

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.

UNCLASSIFIED

Cold Plates

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 (NAA).

Control Electronics Assembly

Consists of one power transformer, one relay and diode module and a bracket end connector mounted behind G&N indicator control panel to support display and control functions. Includes moisture-proofing.

Coolant Hoses

Consists of: (1) three steel-flex coolant hoses between IMU and spacecraft, (2) line transition piece, (3) bracket assembly screws and clamp, and (4) entrapped coolant. (The line transition piece makes two of the hoses a single unit.)

DSKY (D&C/AGC)

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. The main panel DSKY has a piece of fail-safe alarm detection equipment called a "nightwatchman".

D&C Electronics Assembly

Consists of a chassis, a relay and diode module, a demod. elect. module, a saturable reactor, a time delay module, a connector, and wiring and is mounted behind the G&N Indicator Control Panel. Used to support display and control functions. Connectors will be moisture-proofed.



# UNCLASSIFIED

## G&N Indicator Control Panel

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

## G&N Interconnection Assembly

Consists of an 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.

## G&N to S/C Interface Assembly

Cable interconnection between the spacecraft wiring channel, the computer connector, and the PSA end connector. Contains no active electronics. The weight of this item is included with the Block I computer.

## Horizontal Hand Holds

Two hand holds on the G&N Indicator Control 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. The weight includes the mounting screws.

## Inertial Measurement Unit (IMU)

The IMU consists of three gyros and three accelerometers mounted on the innermost gimbal of a three degree-of-freedom gimbal structure. The size 14 IMU (14-inch case diameter) gimbal assembly including all parts inside hermetic case, entrapped coolant, and heat exchanger insulation are included in the weight.

IMU Control Panel

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

NVB and Resilient Mounts

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.

Optical Eyepiece - Long Eye-Relief

Consists of an SCT eyepiece to provide eye relief of at least 1.6 inches for closed visor operation. Used in place of normal eyepiece of SCT.

Optical Eyepiece - Normal Eye-Relief

Removable SXT eyepiece and SCT eyepiece.

Optical Eyepiece Storage Assy

A polyurethane filled structure will provide storage for three optical eyepieces: SXT normal eye-relief, SCT normal eye-relief, and SCT long eye-relief eyepieces. The condition annunciator assembly is part of the compartment structure. The weight also includes a protective cover or door. The assembly is located in the area vacated by the M&DV.

Optical Subsystem

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.

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.

Optical Shroud & Cover Assembly

Consists of the optical shroud and protective cover.

Power Servo Assembly (PSA)

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

UNCLASSIFIED

PSA .End Connector Assembly

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.

PSA Covers

Ten connector covers, gaskets, and mounting screws (one for each tray) for moisture-proofing. Weight included in PSA weight value.

Signal Conditioner Assembly

Conditions signals for telemetry.

UNCLASSIFIED

UNCLASSIFIED

## COMMAND MODULE BLOCK II

### Apollo Guidance Computer (AGC)

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.

Many Block I modules have been redesigned and repackaged in a separate case. The CDUs are on the same side of the cold plate as the AGC. Memory capacity increased over Block I.

### Bellows Assembly

Consists of two elastomeric, semi-toroidal, strain isolation, pressure vessel penetration seals between the CM hull and the optical subsystem.

### Coupling Data Unit Assembly (CDU)

The coupling data unit provides central data conversion between the G&N analog subsystems (inertial and optics sextant), and in addition certain spacecraft analog control and display functions. The CDU is an all-electronic device that employs analog computational techniques in conjunction with digital counters and control logic to perform both analog to digital (A/D) and digital analog (D/A) conversion.

Moding of various Guidance and Control system functions that operate in conjunction with the CDU signals is accomplished by the computer through the CDU control and synchronizing logic.

The weight includes all the support electronics, the 4 V power supply, and the header mounted adjacent to the AGC.

UNCLASSIFIED

Cold Plates

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. (NAA).

Coolant Hoses

Consists of: (1) two steel-flex coolant hoses, between IMU and spacecraft and (2) entrapped coolant. (Bracket assembly, screws and clamps will be supplied by NAA)

DSKY (D&C/AGC)

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.

Mechanically and electrically similar to Block I but smaller configuration because of smaller relays. The Block II displays and keyboard controls will be sealed by encasing the unit in a container and using pressurized O-rings.

G&N Indicator Control Panel

Consists of controls and displays for optics, condition lamps, telemetry, and Master Alarm. Also contains attitude impulse switch and hand controller. Has integral illuminated computer instructions. The condition lamps replace the Block I Condition Annunciator Assembly.

G&N Interconnect Harness Assembly

Consists of eight cables that electrically tie together the assemblies that make up the G&N system and interface with the spacecraft.

Horizon Photometer (Experimental Basis Only)

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 SNT, the weight of which includes this function. The PSA includes all support electronics for the horizon photometer.

Horizontal Handholds

Two handholds on the G&N Indicator Control Panel for use during navigation sightings. These handholds are part of the body of the tethering system for the S/C and will be removed during flight. The weight includes the mounting screws.

Inertial Measurement Unit (IMU)

The IMU consists of three gyros and three accelerometers mounted on innermost gimbal of a three degree-of-freedom gimbal structure. The size 12.5 IMU (12.5-inch case diameter) gimbal assembly including all parts inside the hermetic case, entrapped coolant, and heat exchanger insulation are included in the weight.

NVB & Mounts

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.

Optical Eyepieces - Long Eye-Relief

Consists of an SCT eyepiece to provide eye relief of at least 1.6 inches for closed visor operation. Used in place of normal eyepieces of SCT.

Optical Eyepieces - Normal Eye-Relief

Removable SXT eyepiece and SCT eyepiece.

Optical Eyepiece Storage Assembly

A storage unit for eyepieces is provided similar to the Block I (100 Series) unit. There is no provision for the Condition Annunciator Assembly as part of the compartment structure.

Optical Subsystem

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. (See Horizon Photometer Electronics.)

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.



Optical Shroud & Cover Assembly

Contains an optical shroud. The optics cover is to be used also as a work table during the flight. NAA has design responsibility for the "optics cover - work table".

PIPA Electronics Assembly (PEA)

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.

Power Servo Assembly (PSA)

Similar in function to Block I except that CDU servos are deleted. Electronics to support the PIPA loop have been transferred. See "PIPA Electronics Assembly". Consists of a single plane matrix header with a cold plate mounted on top with the modules plugging from beneath. Many of the modules have been redesigned and repackaged. Contains all the electronics for the experimental horizon photometer - star tracker electronics.

PSA End Connector Assembly

Not identified as a separate item; will be part of the PSA matrix header.

PSA Covers

A cover is required for moisture-proofing during flight. Weight is reported in PSA weight value.

UNCLASSIFIED

Signal Conditioner Assembly

Conditions signals for telemetry. These modules are located in the same volume now occupied by the Block I lower equipment bay DSKY.

UNCLASSIFIED

UNCLASSIFIED

## LUNAR EXCURSION MODULE

### Apollo Guidance Computer (LGC)

A single complete flight computer containing all logic, memory associated power supplies, and all interface circuits except those identified with the CDUs. 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.

This package is consistent with Block II design and the CDUs are on the same side of the cold plate as the AGC.

### Alignment Optical Telescope (AOT)

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

### Bellows Assembly

Consists of an elastomeric, semi-toroidal, strain isolation, pressure vessel penetration seal between the LEM hull and the AOT. This weight is included in the AOT value.

### Cold Plates

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. (GAEC)

UNCLASSIFIED

# UNCLASSIFIED

## Computer Control and Reticle Dimmer Assy (Button Box)

Located on GAEC Supplied Hardware protecting the AOT. Contains illuminated push button controls mark "x", mark "y", and "reject" mark. Also has an AOT reticle dimmer.

## Coolant Hoses

The coolant hoses for the LEM IMU will be supplied by the spacecraft manufacturer. (GAEC)

## Coupling Data Unit (CDU)

The coupling data unit provides central data conversion between the computer and G&N analog subsystems (inertial and radar), and in addition certain spacecraft analog control and display functions. The CDU is an all-electronic device that employs analog computational techniques in conjunction with digital counters and control logic to perform both analog to digital (A/D) and digital to analog (D/A) conversion.

Moding of various Guidance and Control system functions that operate in conjunction with the CDU signals is accomplished by the computer through the CDU control and synchronizing logic.

The LEM CDU is physically identical to CM Block II CDU's except for the headers which contain different module interwiring. The weight includes all the support electronics, the 4V power supply, and the header mounted adjacent to the AGC.

## DSKY

Number Displays and Keyboard controls associated with the operation of the LGC. The DSKY will be sealed by encasing the unit in a container and using pressurized O-rings. Identical to the Block II DSKY except only a single unit is required.

UNCLASSIFIED

## G&N Interconnection Assembly

Consists of two harness assemblies. Harness "A" provides interconnection in the CDU, AGC, and PSA areas. In order to solve EMI problems, there is a filter, located in the distribution box. Harness "B" connects the IMU and PTA areas. The estimated weights include connectors, distribution box, wire, insulation, shielding, and cable clamps.

## Inertial Measurement Unit (IMU)

The IMU consists of three gyros and three accelerometers mounted on the innermost gimbal of a three-degree-of-freedom gimbal structure. The size 12.5 LEM IMU is physically identical to the Block II. The weight value includes the gimbal assembly (and all parts inside the hermetic case), entrapped coolant, and the heat exchanger insulation.

## Lens Cleaning Kit

Not specifically defined but appropriate cloths for cleaning the accessible surfaces of the optics lens.

## NVB and Mounts

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 (normal eye relief)

Included as part of the AOT weight.

UNCLASSIFIED

Power Servo Assembly (PSA)

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

Not identified as a separate item; will be part of the PSA matrix header.

PSA Covers

Cover required for moisture-proofing during flight. Weight is reported in PSA weight value.

Pulse Torque Assembly (PTA)

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

Conditions signals for telemetry. This assembly is identical to Block I and is located on top of the LEM PSA.

**CONFIDENTIAL**

SECTION 4

RELIABILITY

The current status of reliability is reported in summary form as charts.

The following charts contain tabulations of the failure rates associated with each major configuration of G&N systems. These have been derived from the parts counts of each assembly using generic type part failure rates, modified only by the stress applied to each part and its singular application in the system. From these data, estimations of probabilities of mission success have been derived. Continual updating is accomplished and will be reported monthly in this report.

The numerical reliability objectives for the G&C system are provided by NASA/MS-C-ASPO TWX PR 2-64-314 of 5 August 1964. It should be noted that these values are associated with an outdated configuration having a redundant computer. The latter was deleted by NASA direction as part of the interface realignment. The Lunar Orbit Rendezvous numerical reliability mission success objectives are as follows:

Command Module	0.985
Lunar Excursion Module	0.994

This document contains information which, if disclosed, could result in the identification of the source of the information and the disclosure of the information to unauthorized persons. The transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by Law.

**DOWNGRADED AT 3 YEAR INTERVALS  
DECLASSIFIED AFTER 12 YEARS**

DDO DIR 5200 10

CONFIDENTIAL

TABLE 4. RELIABILITY ESTIMATES FOR APOLLO MISSION FLIGHT 202  
UNMANNED MISSION †  
(Probability of Success of G&N System 17 from Earth Launch Until CM  
Splashdown)

G&N Subsystems	Operate Failure Rate Per 10 <sup>6</sup> hrs	Operate Time (hours)	Failures per 10 <sup>6</sup> Missions	Success Probability
IMU	185	1.4	259	.99974
IMU Electronics	224	1.4	314	.99968
CDU (IMU)	111	1.4	155	.99984
Optics	---	0	0	---
Optics Electronics	---	0	0	---
CDU (Optics)	---	0	0	---
AGC	257	1.4	360	.99964
DSKY (2)	12	1.4	17	.99998*
D&C	6	1.4	8	.99999
TOTAL			1113	.9988

† Based upon NASA approved MIT Report R-477, "G&N System Operations Plan Apollo Mission 202"

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

CONFIDENTIAL



TABLE 5. RELIABILITY ESTIMATES FOR VARIATIONS OF AMPTF DESIGN REFERENCE MISSION †  
(Probability of success of CSM PGNCs from earth launch until LEM powered descent.)  
(Elapsed time of approximately 69 hours.)

CSM PGNCs Subsystem	Operate Failure Rate Per 10 <sup>6</sup> hrs	Operate Time (hrs)	Standby Failure Rate Per 10 <sup>6</sup> hrs	Standby Time (hrs)	Failures Per 10 <sup>6</sup> Missions	Success Probability
IMU	129	13.8	10.2	55.6	2347	0.99766
IMU Electronics	110	13.8	6.3	55.6	1868	0.99813
CDU (IMU)	155	13.8	0	55.6	2139	0.99861
Optics	94	9.1	0	59.1	855	0.99914
Optics Electronics	77	9.1	0	59.1	701	0.99929
CDU (Optics)	91	9.1	0	59.1	828	0.99917
AGC	235	13.8	60.5	55.6	6607	0.9931*
DSKY (2)	2.3 Equiv.	13.8	0	55.6	2	0.99999
D&C	22	13.8	0	55.6	304	0.99969
TOTAL					15,652	0.9844

†Based upon the latest Apollo Mission Planning Task Force - Design Reference Mission - (GAEC Report LED-540-12, Vol. III dated 30 October 1964) as modified by NASA letter EG 131-5-65-374.

\* Success requires that only one of redundant pair of DSKYs not fail.

TABLE 6. RELIABILITY ESTIMATE FOR LEM G&N BASED ON AMPTF DESIGN REFERENCE MISSION †  
(Probability of success for LEM PGNCS from earth launch until LEM touchdown.)

LEM PGNCS Subsystem	Operate Failure Rate Per 10 <sup>6</sup> hrs	Operate Time (hrs)	Standby Failure Rate Per 10 <sup>6</sup> hrs	Standby Time (hrs)	Failures Per 10 <sup>6</sup> Missions	Success Probability
IMU	129	3.25	1.6	66.2	525	0.9995
IMU Electronics	110	3.25	0	0	357	0.9997
CDU (IMU)	155	3.25	0	0	504	0.9995
AOT	38	3.25	0	0	124	0.99988
AOT Electronics	1.33	3.25	0	0	4	0.99999
CDU (Rendezvous Radar)	112	3.25	0	0	364	0.9997
LGC	235	3.25	0	0	764	0.9992
DSKY	110	3.25	0	0	358	0.9996
D&C	7	3.25	0	0	23	0.99998
TOTAL					3008	0.9970

† Based upon the latest Apollo Mission Planning Task Force - Design Reference Mission - (GAEC Report LED-540-12, Volume III, dated 30 October 1964) as modified by NASA letter EG-131-5-65-374.

# UNCLASSIFIED

## SECTION 5

### GUIDANCE COMPUTER PROGRAMMING

The latest memory allocation for Command Module AGC programs will be presented in tabular form with only the more significant programs itemized.

The list includes many servicing programs that are necessary for the general operation of the computer. A few examples of these utility programs will demonstrate their usefulness:

List Processing Interpreter - translates AGC programs into a parenthesis - free pseudocode notation for economy of storage

AGC Executive - the function of this program is to control priority of jobs, to permit time sharing of erasable storage, and to maintain a display signal denoting "computer activity".

AGC Waitlister - the function of the waitlister is to provide timing control for other program section.

Also listed are programs capable of performing PGNS tests and mission guidance and navigation routines.

The memory also contains all mission, and vehicle, dependent data that are written directly into the memory of the AGC. In a wired memory computer such as the AGC, the very limited erasable section is intended primarily for storage of computational variables. An attempt has been made to consign those mission parameters that do not change during flight, to the fixed section of the memory. Some exceptions have to be made since some data is not available until shortly before flight.

UNCLASSIFIED

FLIGHT 202

The guidance routines for the various mission phases were incorporated within the 202 mission control program section of program CORONA as specified in the NASA approved Guidance System Operation Plan presented in MIT Report R-477, "Guidance and Navigation System Operations Plan Apollo Mission 202". The command module computer program memory allocation for Flight 202 is in the process of being calculated and will be reported next month when the values become established.

BLOCK II & LEM

The development of "AURORA" Guidance Computer Program started during this reporting period, and will represent the basic Block II guidance computer and will contain the equivalent programs which comprise the SUNRISE 45 assembly for the Block I CSM PGNS. The differences between the LEM assembly (AURORA) and SUNRISE 45 will reflect the differences between the LEM and Block I CSM interfaces with their respective guidance computers and an augmented test capability of the G&N system. In addition, the LEM Guidance Computer program assembly will include limited data computation, servicing routines, and integrated system tests for the following interfaces:

- |                           |                               |
|---------------------------|-------------------------------|
| 1. Rendezvous Radar       | 5. RCS Jets                   |
| 2. Landing Radar          | 6. Ascent and Descent Engines |
| 3. Hand Controller        | 7. Abort                      |
| 4. Inertial Data Displays |                               |

Programs will also be included to perform the following PGNCS tests:

- |                                   |                    |
|-----------------------------------|--------------------|
| 1. Fine Alignment                 | 5. LGC Self Check  |
| 2. PIPA Scale Factor and Bias     | 6. Sum Check       |
| 3. IRIG Torquing Scale Factor     | 7. G&N Operational |
| 4. IRIG Coefficient Determination |                    |

UNCLASSIFIED

# UNCLASSIFIED

The SUNRISE 45 programs which will not be included in the LEM assembly are those associated with the SXT and SCT optics. A description of the SUNRISE program is documented in MIT/IL Report R-467.

A portion of AURORA, designated as RETREAD, has been completed and tapes were released for manufacture. Programs incorporated in RETREAD are:

- |                |                                 |
|----------------|---------------------------------|
| 1. Interpreter | 5. T4 Rupt Program for Displays |
| 2. Executive   | 6. Keyboard Uprupt              |
| 3. Waitlist    | 7. Keyboard and Display         |
| 4. Fresh Start | 8. Instruction Check            |

A general description of the above RETREAD programs is presented in MIT Digital Development Memo 262 (July 7, 1965). The Block II interpreter in this program is described in detail in MIT Report R-489. The keyboard and display section is summarized in Digital Development Memo # 267 (July 28, 1965).

Preliminary estimates of the memory capacity for the Block II AURORA program are being established and will be reported next month.

# UNCLASSIFIED

## SECTION 6

### ELECTRICAL POWER AND ENERGY

Electrical power and energy reporting is based upon the inflight spacecraft sequence of events for the Design Reference Mission as developed by the Apollo Mission Planning Task Force (AMPTF). (Reference GAEC Report Volume III - LED-540-12, dated 30 October 1964.)

The accompanying tables present the magnitude and distribution of power dissipated on a subsystem level. It is assumed that power is drawn from the spacecrafts' primary +28VDC supply and a 400 cps - 115 VAC single phase inverter.

Intermittent power peaks can exist, particularly during operation of displays and controls at random times. The energy content in these peaks is considered negligible.

All values (except those mentioned above) are actual expected levels of power. No margin factor has been applied to protect against possible differences between actual loads which will be experienced and the calculated levels quoted. Thus, these values should not be taken as "not to exceed" extremes.

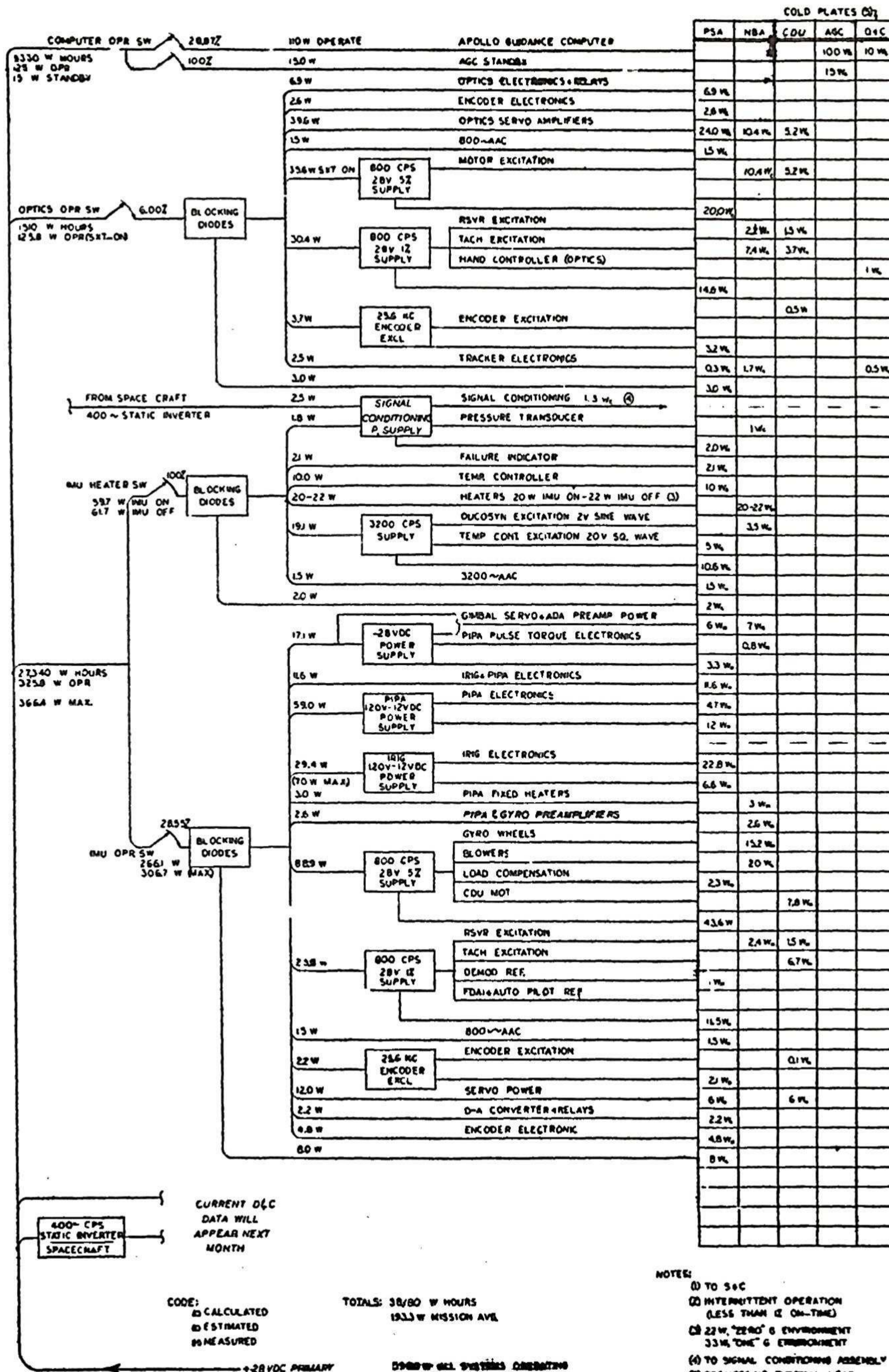
Interface Control Documents serve as the guidelines for reporting power figures.

CM Block I 100 Series	MH01-01227-216 "G & N Electrical Input Power" signed 11 June 1965
CM Block II	MH01-01327-216 "G & N Electrical Input Power" signed 15 July 1965
LEM	LIS-390-10002 "PGNCS Prime Power Requirements and Characteristics" signed 30 July 1965

## BLOCK I - 100 SERIES GUIDANCE & NAVIGATION LOAD ON PRIMARY +28 VDC - COMMAND MODULE

BASED UPON 198.5 HOUR (827 DAY) LUNAR MISSION  
DESIGN REFERENCE MISSION

REFERENCE GALE REPORT - LEO 640-12, 30 OCTOBER 1968  
APOLLO MISSION PLANNING TASK FORCE

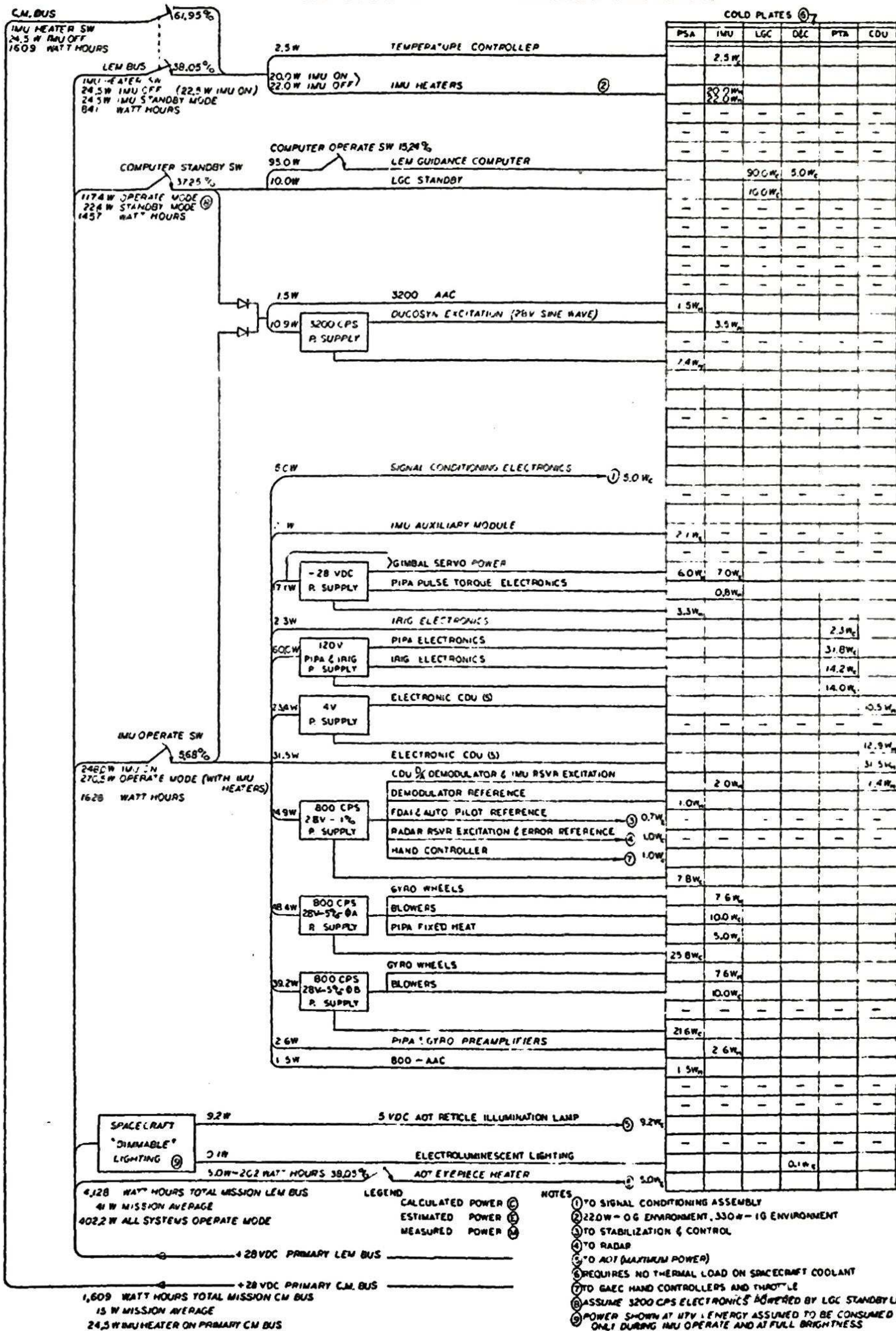






## LUNAR EXCURSION MODULE GUIDANCE & NAVIGATION LOAD ON +28VDC PRIMARY

BASED UPON 106.02 HOURS (4.42 DAY) LUNAR LANDING MISSION — REFERENCE GAEC REPORT - LED 540-12 OCT. 30, 1964  
DESIGN REFERENCE MISSION — APOLLO MISSION PLANNING TASK FORCE



4,128 WATT HOURS TOTAL MISSION LEM BUS  
 41 W MISSION AVERAGE  
 402.2 W ALL SYSTEMS OPERATE MODE  
 +28VDC PRIMARY LEM BUS  
 +28VDC PRIMARY CM BUS  
 1,609 WATT HOURS TOTAL MISSION CM BUS  
 15 W MISSION AVERAGE  
 24.5 W IMU HEATER ON PRIMARY CM BUS

**LEGEND**  
 CALCULATED POWER (C)  
 ESTIMATED POWER (E)  
 MEASURED POWER (M)

**NOTES**

- (1) TO SIGNAL CONDITIONING ASSEMBLY
- (2) 22.0W - OG ENVIRONMENT, 33.0W - IG ENVIRONMENT
- (3) TO STABILIZATION & CONTROL
- (4) TO RADAR
- (5) TO ADT (MAXIMUM POWER)
- (6) REQUIRES NO THERMAL LOAD ON SPACECRAFT COOLANT
- (7) TO GAEC HAND CONTROLLERS AND THROTTLE
- (8) ASSUME 3200 CPS ELECTRONICS POWERED BY LGC STANDBY LINE
- (9) POWER SHOWN AT 117V LINE ENERGY ASSUMED TO BE CONSUMED ONLY DURING IMU OPERATE AND AT FULL BRIGHTNESS

MIT W/65

UNCLASSIFIED

E-1142

Rev 39

DISTRIBUTION LIST

Apollo Internal

Apollo Library (5)	Lawrence, J. (GAEC)
Battin, R.	Lawton, T. J.
Bean, W.	Mayo, G.
Bowditch, P.	Miller, J.
Boyce, A.	MIT/IL Library (IL-1)(8)
Dahlen, J.	Nadler, W. (2)
Dunipace, E.	Nevins, J.
Duggan, E.	Nugent, J.
Feldman, J. B.	Olsson, E. A.
Flanders, J. (MIT/AMR)	Richter, M. (MIT/MSC)
Felix, S. (S&ID)	Schwarm, E.
Hall, E. C.	Sciegienny, J.
Hickey, E.	Sears, N.
Hoag, D.	Stameris, W.
Houston, F.	Stone, J.
Hursh, J.	Trageser, M.
Johnson, L.	Watson, P.
Koso, A.	Wilk, L. (2)
Kramer, M.	Woodbury, R.
Larson, L.	

UNCLASSIFIED

UNCLASSIFIED

E-1142

Rev 39

## DISTRIBUTION LIST

## External:

W. Rhine (NASA/MSC)	(2)
NASA/RASPO	(1)
L. Holdridge (NAA/MIT)	(1)
T. Heuermann (GAEC/MIT)	(1)
AC Electronics	(10)
Kollsman	(10)
Raytheon	(10)
Major H. Wheeler (AFSC/MIT)	(1)
MSC:	(30 + 1R)
National Aeronautics and Space Administration Manned Spacecraft Center Apollo Document Distribution Office (PA2) Houston, Texas 77058	
KSC:	(1R)
NASA J. F. Kennedy Space Center Technical Document Control Office, HB-23 Cape Kennedy, Florida	
GAEC:	(3 + 1R)
Grumman Aircraft Engineering Corporation Data Operations and Services, Plant 25 Bethpage, Long Island, New York Attn: Mr. E. Stern	
NAA:	(18 + 1R)
North American Aviation, Inc. Space and Information Systems Division 12214 Lakewood Boulevard Downey, California Attn: Apollo Data Requirements AE99 Dept. 41-096-704 (Bldg 6)	

# UNCLASSIFIED

NAA RASPO: (1)

NASA Resident Apollo Spacecraft Program Office  
North American Aviation, Inc.  
Space and Information Systems Division  
Downey, California 90241

ACSP RASPO: (1)

National Aeronautics and Space Administration  
Resident Apollo Spacecraft Program Officer  
Dept. 32-31  
AC Electronics Division of General Motors  
Milwaukee 1, Wisconsin  
Attn: Mr. W. Swingle

Mr. H. Peterson (1)  
Bureau of Naval Weapons  
c/o Raytheon Company  
Foundry Avenue  
Waltham, Massachusetts

Queens Material Quality Section (1)  
c/o Kollsman Instrument Corporation  
Building A 80-08 45th Avenue  
Elmhurst, New York 11373  
Attn: Mr. S. Schwartz

D. F. Kohls (1)  
AFPRO (CMRKKA)  
AC Electronics Division of General Motors  
Milwaukee 1, Wisconsin 53201

# UNCLASSIFIED