

MISSION PLANNING AND ANALYSIS DIVISION

No.

MSC ROUTING SLIP										Due Date	
Circulate	Coordination	File	Read	Necessary Action	Note and Return	See Me	Signature	Comply			
Name or Title			Initial	Date	Name or Title			Initial	Date		
OFFICE OF CHIEF					FAB		FM3				
Mayer					Hicks						
Tindall					MPB		FM4				
Huss					McPherson						
Jenkins					LMAB		FM5				
Knoblauch					Frank						
ADMINISTRATIVE OFFICE					Ernull						
Ritz					OMAB		FM6				
Patterson					Lineberry						
REPORT PREPARATION OFFICE					GPB		FM7				
Burton					Cassetti						
MPSO			FML3		Mann						
Parten					AMDB						
McAnulty					Funk						
Thueson											
Goodwin											
LLB			FM2								
Bennett											
REMARKS:											
From			MAR 11 RECD				Phone		Date		

MSC Form 467 (Jul 62)

No.

MSC ROUTING SLIP										GUIDANCE & PERFORMANCE BRANCH		Due Date	
Circulate	Coordination	File	Read	Necessary Action	Note and Return	See Me	Signature	Comply					
Name or Title			Initial	Date	Name or Title			Initial	Date				
GPB BRANCH CHIEF					Kamen								
Cassetti			M	3-12	Kolkhorst								
Mann			Jpm	3-12	Loyd								
GUIDANCE ANALYSIS					Mayfield								
Nobles				3-19	Nelson								
Beggs					Peterson (AF)								
Bordano					Scott								
Estes					Stokes								
Ford (AF)					Swalin								
Graf					Wadle								
Heetderks													
Miles													
Montez					FLIGHT DISPERSION								
Moore					O'Loughlin								
Wells					Accola								
					McHenry								
					Nolley								
CONSUMABLES ANALYSIS					Rother								
Brown					Parker (AF)								
Alexander													
Andrews													
Beal													
REMARKS:													
FILE _____													
DESTROY _____													
RETURN TO <u>SANDY</u> FOR FILE!													

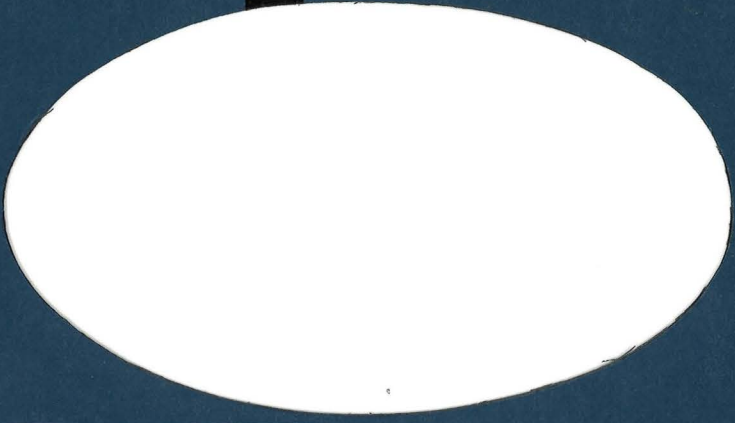
MSC Form 467 (Jul 62)

FM/J.P. MAYER

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

APOLLO

GUIDANCE, NAVIGATION AND CONTROL



CAMBRIDGE 39, MASSACHUSETTS

INSTRUMENTATION LABORATORY

APOLLO

GUIDANCE, NAVIGATION AND CONTROL

Approved: L. E. Larson, Jr. Date: 30 Jan 68
L. E. LARSON, JR., MANAGEMENT DIRECTOR
APOLLO GUIDANCE AND NAVIGATION PROGRAM

Approved: David G. Hoag Date: 8 Feb 68
DAVID G. HOAG, DIRECTOR
APOLLO GUIDANCE AND NAVIGATION PROGRAM

Approved: Ralph R. Ragan Date: 12 Feb 68
RALPH R. RAGAN, DEPUTY DIRECTOR
INSTRUMENTATION LABORATORY

E-1142
(Rev. 54)

SYSTEM STATUS REPORT

December 1967

MIT INSTRUMENTATION LABORATORY
CAMBRIDGE 39, MASSACHUSETTS

ACKNOWLEDGEMENT

This report was prepared under DSR Project 55-23870, sponsored by the Manned Spacecraft Center of the National Aeronautics and Space Administration through Contract NAS 9-4065 with the Instrumentation Laboratory of the Massachusetts Institute of Technology in Cambridge, Massachusetts.

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.

E-1142
(Rev. 54)

SYSTEM STATUS REPORT

ABSTRACT

The System Status Report is normally distributed bimonthly. The areas of activity reported on in this month's revision include, but are not limited to, the following for the Block 1 100 Series and Block II Command Modules and Lunar Excursion Module equipment: configuration weight, weight trend information, reliability failure rates, electrical power requirements, computer programming status, and G&N Status.

by Apollo Staff
December, 1967

TABLE OF CONTENTS

<u>Section</u>		<u>Page</u>
1	Configuration Weights	11
2	Glossary and System Definition	19
3	Reliability - Failure Rates	21
4	Electrical Power Requirements	23
5	Guidance and Navigation Systems Status	27
6	G&N System Test	33
7	G&N Computer Status	41
8	Guidance Computer Programming	45
9	List of "E" and "R" Notes Published During Reporting Period	57

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 slight variations from system to system.

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 Module equipment:

- Section 1 - Configuration Weights
- Section 2 - Glossary and System Definition
- Section 3 - Reliability - Failure Rates
- Section 4 - Electrical Power Requirements
- Section 5 - Guidance and Navigation Systems Status
- Section 6 - G&N System Test
- Section 7 - G&N Computer Status
- Section 8 - Guidance Computer Programming
- Section 9 - List of "E" and "R" Notes Published During Reporting Period

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

SECTION 1
CONFIGURATION 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 LM 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. The weights tabulated for Block II CM and LM configuration represent operational flight hardware.

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.

When applicable, the tables will be followed by a discussion of reported weight changes and weight trend information. Each weight increase or decrease is accompanied with an explanation for the change and the effectivity by system number. Weight trend information describes future component changes presently being studied with an emphasis on weight reduction proposals.

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

Reported Weight Changes and
Weight Trend Information

Block II

1. The following weight changes are estimated as a result of design changes to decrease flammability hazards. Because of the uncertainty in the estimates, these changes are not being included in the charts at this reporting.

CM Harness	+2.50
GNIC Panel	NA
Optics Shroud	NA
Eyepiece Stowage Unit	NA
IMU	-0.54
Hoses	-0.20
Eyepieces	NA
PSA	+0.25
PEA	+0.01
DSKY	NA
SCA	+0.02

TABLE 1. CURRENT WEIGHT STATUS OF BLOCK I 100 SERIES
COMMAND MODULE G&N (LBS AT 1G)

Command Module G&N Equipment	Status 10/67	Change	Status 12/67	Design Load Weight*
LOWER EQUIPMENT BAY				
CDU Assy	16.9 (M)	0.0	16.9 (M)	18.0 [#]
Optical Subsystem				} 155.0 ^{**}
SXT and gearing	54.6 (M)	0.0	54.6 (M)	
SCT and gearing				
Optical Base and gearing				
NVB and Resilient Mounts	25.7 (M)	0.0	25.7 (M)	
Bellows Assy	10.7 (M)	0.0	10.7 (M)	
IMU	61.2 (M)	0.0	61.2 (M)	
Coolant Hoses (Three)	1.4 (M)	0.0	1.4 (M)	
Power Servo Assy	65.4 (M)	0.0	65.4 (M)	} 120.0
G&N Interconnection Assy	26.1 (M)	0.0	26.1 (M)	
Optical Shroud	3.1 (M)	0.0	3.1 (M)	4.5
G&N to S/C Interface Assy	90.8 (M)	0.0	90.8 (M)	100.0
CMC (with 6 rope modules)				
Optical Eyepiece Storage Assy	12.7 (M)	0.0	12.7 (M)	15.0
Condition Annunciators				
SXT Normal Relief Eyepiece				
SCT Normal Relief Eyepiece				
SCT Long Relief Eyepiece				
D&C Electronics Assy	2.6 (M)	0.0	2.6 (M)	5.0
Control Electronics Assy	1.8 (M)	0.0	1.8 (M)	4.0

TABLE 1. CURRENT WEIGHT STATUS OF BLOCK I 100 SERIES
COMMAND MODULE G&N (LBS AT 1G) (CONT)

Command Module G&N Equipment	Status ^{1/} 10/67	Change	Status ^{2/} 12/67	Design Load Weight [*]
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
Signal Conditioner Assy	4.8 (M)	0.0	4.8 (M)	8.0
DSKY	24.5 (M)	0.0	24.5 (M)	26.0
MAIN PANEL AREA				
DSKY	25.3 (M)	0.0	25.3 (M)	26.0
LOOSE STORED ITEMS				
Optics Cover	2.1 (M)	0.0	2.1 (M)	2.5
Horizontal Hand Holds (Two)	0.3 (M)	0.0	0.3 (M)	1.0
TOTAL	443.8	0.0	443.8	---
The reported total weight for this month is 13.8 pounds more than the 430.0 pound total control weight †				
Bare Guidance Systems - IMU, AGC, IMU portions of the CDU's and IMU Support electronics			206.4	---

* Design Load Weights are taken from ICD MH01-01256-416 signed 3 June 1965, submitted by MIT in letter AG 478-65.

** This design load weight includes only 1/2 the weight of the Bellows Assembly.

† The Total Control Weight is specified in NASA letter EG-151-44-65-55 dated 10 February 1965. This weight assignment does not include recognition of the Optical Eyepiece Storage Assembly.

This design load weight taken from IRN 3677, submitted by MIT in Letter AG 407-66 dated 9 May 1966.

DATE: December 1967

TABLE 2. CURRENT WEIGHT STATUS OF BLOCK II
COMMAND MODULE GN&C (LBS AT 1G)

Command Module GN&C Equipment	Status 10/67	Change	Status 12/67	Design Load Weight *
LOWER EQUIPMENT BAY				
CDU Assy	36.5 (M)	0.0	36.5 (M)	50.0
Optical Subsystem	55.7 (M)	0.0	55.7 (M)	150.0
SXT and gearing				
SCT and gearing				
Optical Base and gearing				
APTPS and Dust Covers	17.4 (M)	0.0	17.4 (M)	
NVB and Mounts	10.7 (M)	0.0	10.7 (M)	
Bellows Assy	42.5 (M)	0.0	42.5 (M)	
IMU	1.2 (M)	0.0	1.2 (M)	
Coolant Hoses (Two)	49.4 (M)	0.0	49.4 (M)	58.0
Power Servo Assy	9.0 (M)	0.0	9.0 (M)	12.0
PIPA Electronics Assy	24.0 (M)	0.0	24.0 (M)	40.0
G&N Interconnect Harness Group	70.1 (M)	0.0	70.1 (M)	80.0
AGC (with six(6) rope modules + mag. trays)	3.1 (M)	0.0	3.1 (M)	4.5
Optical Shroud	14.0 (M)	0.0	14.0 (M)	15.0
Optical Eyepiece Storage Assy				
SXT Normal Relief Eyepiece				
SCT Normal Relief Eyepiece				
SCT Long Relief Eyepiece	11.5 (M)	0.0	11.5 (M)	17.0
G&N Indicator Control Panel	17.5 (M)	0.0	17.5 (M)	25.0
DSKY	5.8 (M)	0.0	5.8 (M)**	8.0
Signal Conditioner Assy (Operational Flights)				

TABLE 2. CURRENT WEIGHT STATUS OF BLOCK II
COMMAND MODULE GN&C (LBS AT 1G) (CONT)

Command Module GN&C Equipment	Status 10/67	Change	Status 12/67	Design Load Weight*
MAIN PANEL AREA				
DSKY	17.5 (M)	0.0	17.5 (M)	25.0
LOOSE STORED ITEMS				
Horizontal Hand Holds (Two)	0.3 (M)	0.0	0.3 (M)	1.0
TOTAL	386.2	0.0	386.2	---
The reported total weight for this month is 13.8 pounds less than the 400.0 pound total control weight †				
Bare Guidance Systems - IMU, AGC, IMU portions of the CDUs and IMU support electronics			172.8	---

*Design Load Weights are taken from ICD MH01-01356-416 signed 16 July 1965 at Meeting #22A.

**The weight of a qualification flight signal conditioner assy is 8.6(M) pounds.

† The Total Control Weight is specified in NASA letter EG-151-44-65-55 dated 10 February 1965. This weight assignment does not include recognition of the Optical Eyepiece Storage Assembly.

DATE: December 1967

Reported Weight Changes and
Weight Trend Information

LM

1. The following weight changes are estimated as a result of design changes to decrease flammability hazards. Because of the uncertainty in the estimates, these changes are not being included in the charts at this reporting.

Harnesses	+1.40
CCRD	+0.05
IMU	-0.54
AOT	+0.20
PTA	+0.01
SCA	+0.01
DSKY	Not Available

TABLE 3. CURRENT WEIGHT STATUS OF LM PGNCS (LBS AT 1G)

LM PGNCS Equipment	Status 10/67	Change	Status 12/67	Design Load Weight*
IMU	42.4 (M)	0.0	42.4 (M)	} 80.0
AOT (including eyepiece and bellows)	23.1 (M)	0.0	23.1 (M)	
NVB	5.1 (M)	0.0	5.1 (M)	
HARNESS "B" Supported by the NVB	0.6 (E)	0.0	0.6 (E)	} 21.0
HARNESS "B" Supported by the PTA	0.8 (E)	0.0	0.8 (E)	
HARNESS "B" Supported by the structure	3.1 (E)	0.0	3.1 (E)	
PTA	14.3 (M)	0.0	14.3 (M)	} 22.0
HARNESS "A"	14.6 (M)	0.0	14.6 (M)	
LGC (with six(6) rope modules + mag trays)	70.6 (M)	0.0	70.6 (E)	65.0
DSKY	17.5 (M)	0.0	17.5 (M)	20.0
AOT Control Unit (CCRD)	1.6 (M)	0.0	1.6 (M)	2.0
CDU	37.5 (M)	0.0	37.5 (M)	37.0
PSA	17.5 (M)	0.0	17.5 (M)	} 28.2
SCA (Operational Flights)	5.5 (M)	0.0	5.5 (M)	
TOTAL	254.2	0.0	254.2	---
The reported total weight for this month exceeds the 245.0 pounds total control weight by 9.2 lbs.†				
Bare Guidance Systems - IMU, LGC, IMU portions of the CDUs and IMU support electronics			167.9	

* Design Load Weights are taken from ICD LIS-490-10001 as signed by Mr. R. A. Gardner (NASA/ MSC) on 29 March 1966.

** The weight of a qualification flight signal conditioner assy is 7.8 (M) pounds.

† The Total Control Weight is specified in Contract Technical Specification PS 6000000 - amended by NASA Letter EG 26-233-66-565 dated 18 August 1966.

DATE: December 1967

SECTION 2

GLOSSARY AND SYSTEM DEFINITION

The description at what constitutes the MIT Guidance and Navigation equipment in Block I (100 series), Block II Command Modules and Lunar Modules has been defined in previous System Status reports. This Section will be updated when any significant changes are made in the systems.

SECTION 3

RELIABILITY FAILURE RATES

The current status of reliability analysis is reported in summary form as a chart.

This chart contains tabulations of the failure rates associated with each major configuration of G&N systems. These have been derived from the parts count 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 mission success probabilities may be calculated. Continual updating is accomplished and will be reported monthly in this report.

G&N MISSION RELIABILITY ANALYSIS
FAILURE RATES EXPRESS IN "FAILURES PER 10⁶ HOURS"

MISSION		IMU Assembly	IMU Electronics (PSA)	Optics Assembly	Optics Electronics (PSA)	IMU CDU	Optics CDU	AGC	DSKY	D&C	Mission Reliability
		ON / STBY	ON / STBY	ON / OFF	ON / OFF	ON / STBY	ON / OFF	ON / STBY	ON / OFF	ON / OFF	
AGE 122 FLIGHT 501 UNMANNED	OPER HRS λ	8.63 - 195 -	8.63 - 224 -	- - - -	- - - -	8.63 - 111 -	- - - -	8.63 - 257 -	8.63 - 12 -	8.63 - 6 -	.9931
AGE 123 FLIGHT 502 UNMANNED	OPER HRS λ	8.3 - 195 -	8.3 - 224 -	- - - -	- - - -	8.3 - 111 -	- - - -	8.3 - 257 -	8.3 - 12 -	8.3 - 6 -	.9933
C/M FLIGHT 503 MANNED	OPER HRS λ	31.3 208 129 10.2	31.3 208 110 6.3	14.2 225 94 -	14.2 225 77 -	31.3 208 155 -	31.3 208 91 -	31.3 208 235 60.5	31.3 208 2.3	31.3 208 2.3 -	.9626
L/M FLIGHT 503 MANNED	OPER HRS λ	8.4 120 129 1.6	8.4 - 110 -	8.4 - 38 -	8.4 - 1.33 -	8.4 - 155 -	8.4 - 112 -	8.4 - 235 -	8.4 - 110 -	8.4 - 1.2 -	.9923
AGE 603 FLIGHT 204* UNMANNED LM	OPER HRS λ	9.6 - 129 -	9.6 - 110 -	- - - -	- - - -	9.6 - 155 -	- - - -	9.6 - 235 -	9.6 - 12 -	- - - -	.9938
C/M DES. REF.	OPER HRS λ	13.8 55.6 129 10.2	13.8 55.6 110 6.3	9.1 60.3 94 -	9.1 60.3 77 -	13.8 55.6 155 -	13.8 55.6 91 -	13.8 55.6 235 60.5	13.8 55.6 2.3 -	13.8 55.6 2.3 -	.9840
LM DES. REF.	OPER HRS λ	3.25 66.3 129 1.6	3.25 66.3 110 -	3.25 - 38 -	3.25 - 1.33 -	3.25 - 155 -	3.25 - 112 -	3.25 - 235 -	3.25 - 110	3.25 - 1.2 -	.9969

* 206 REDESIGNATED 204/LM1

DATE: December 1967

SECTION 4

ELECTRICAL POWER REQUIREMENTS

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 power drawn through the spacecraft circuit breakers. It is assumed that power is drawn from the spacecraft's 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 at 28.0 VDC. They are based on measured values on G & N systems 207 and 208 for the Block II Command Module and G & N systems 608, 600, and LM learner for the LM. No margin factor has been applied to protect against possible differences between G & N systems and spacecrafts. Thus, these values should not be taken as "not to exceed" extremes.

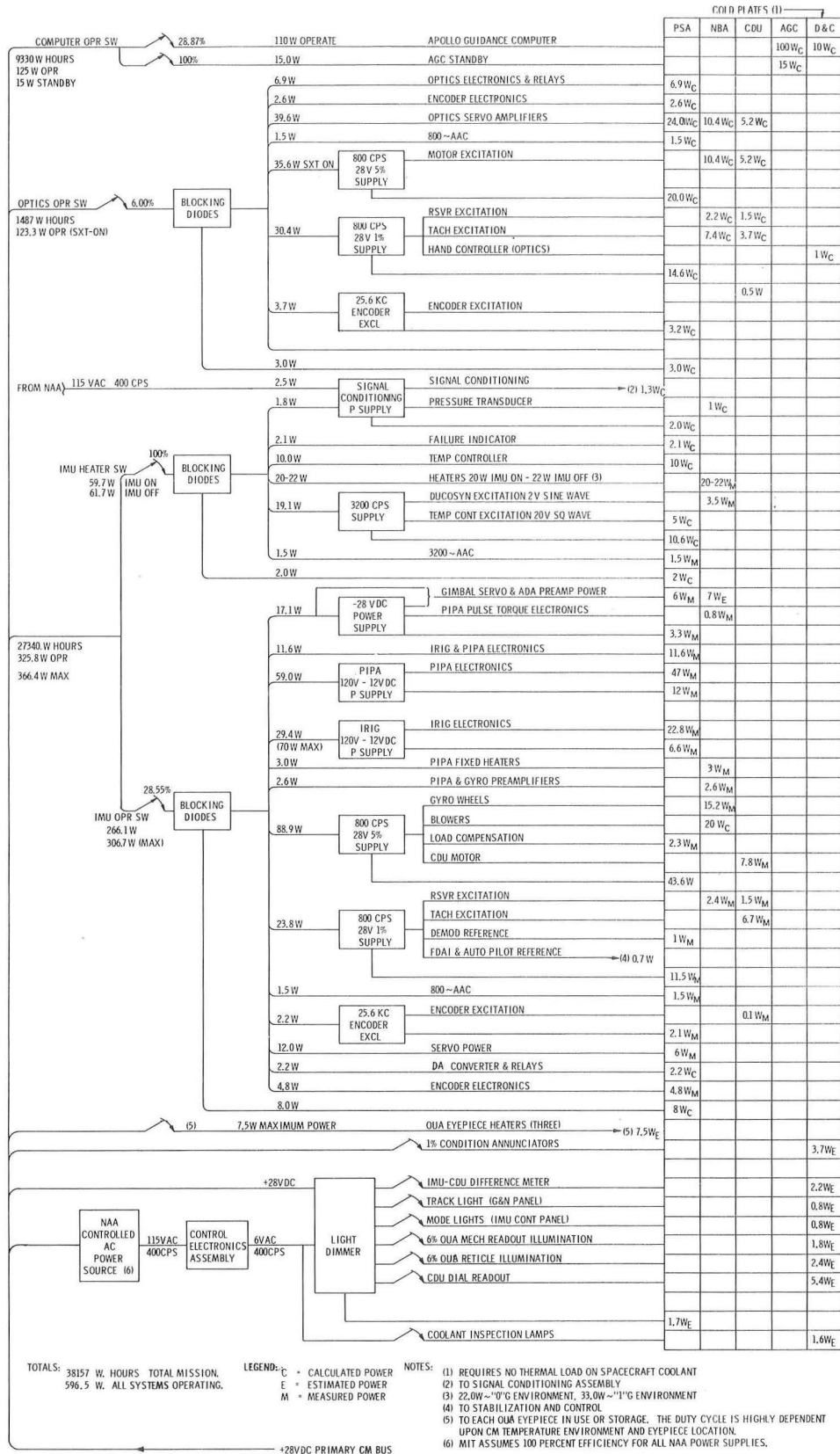
Interface Control Documents serve as the guidelines for reporting power figures.

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
LM	LIS-390-10002 "PGNCS Prime Power Requirements and Characteristics" signed 30 July 1965

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

BASED UPON 198.5 HOUR (8.27 DAY) LUNAR MISSION
DESIGN REFERENCE MISSION

REFERENCE GAEC REPORT - LED 540-12, 30 OCTOBER 1964
APOLLO MISSION PLANNING TASK FORCE

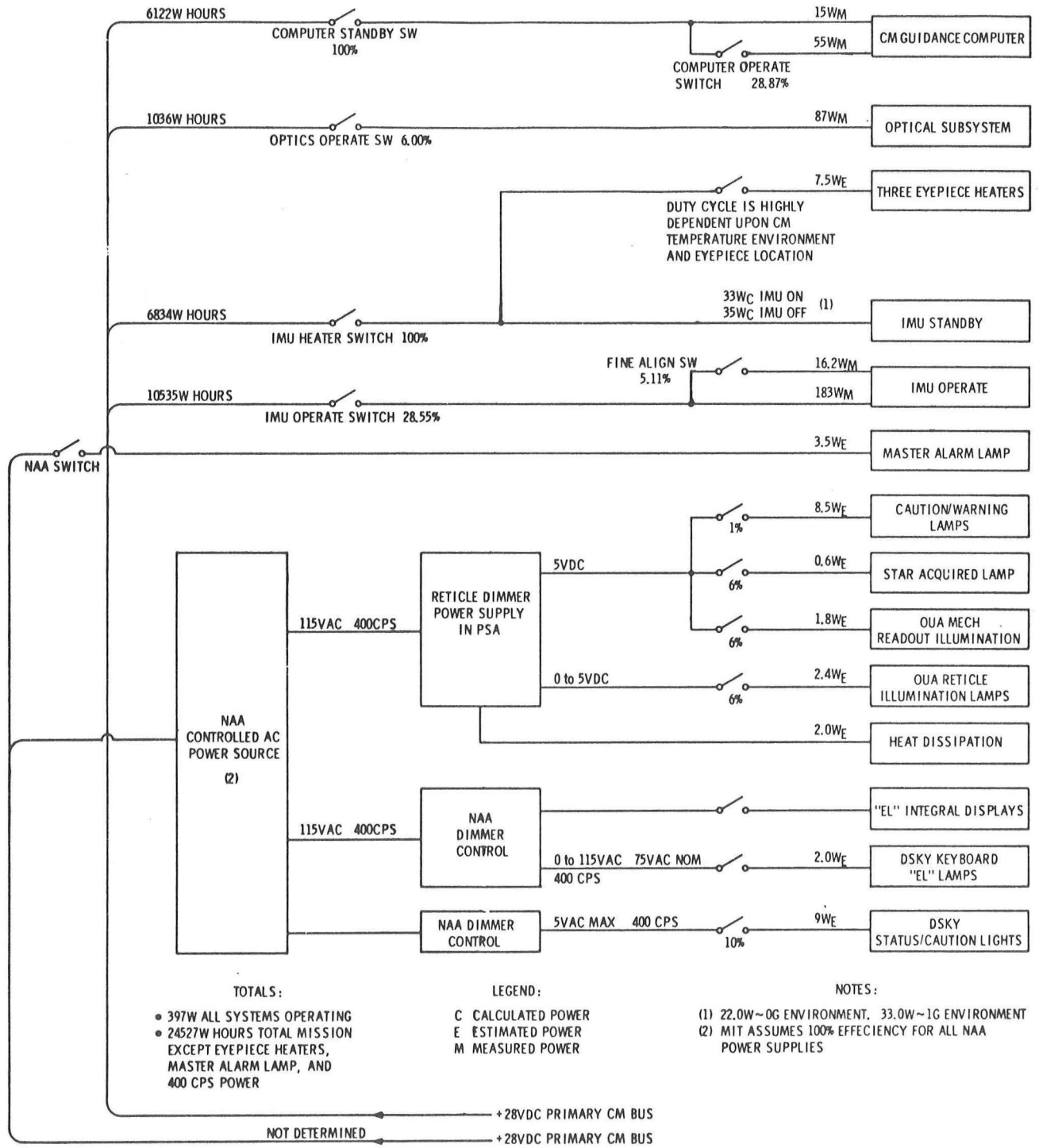


BLOCK II GUIDANCE & NAVIGATION LOAD ON PRIMARY +28 VDC COMMAND MODULE

BASED UPON 198.5 HOURS (8.27 DAY) LUNAR ORBIT MISSION
DESIGN REFERENCE MISSION

STATUS OCTOBER 1967

REFERENCE GAEC REPORT - LED 540-12, 30 OCTOBER 1964
APOLLO MISSION PLANNING TASK FORCE

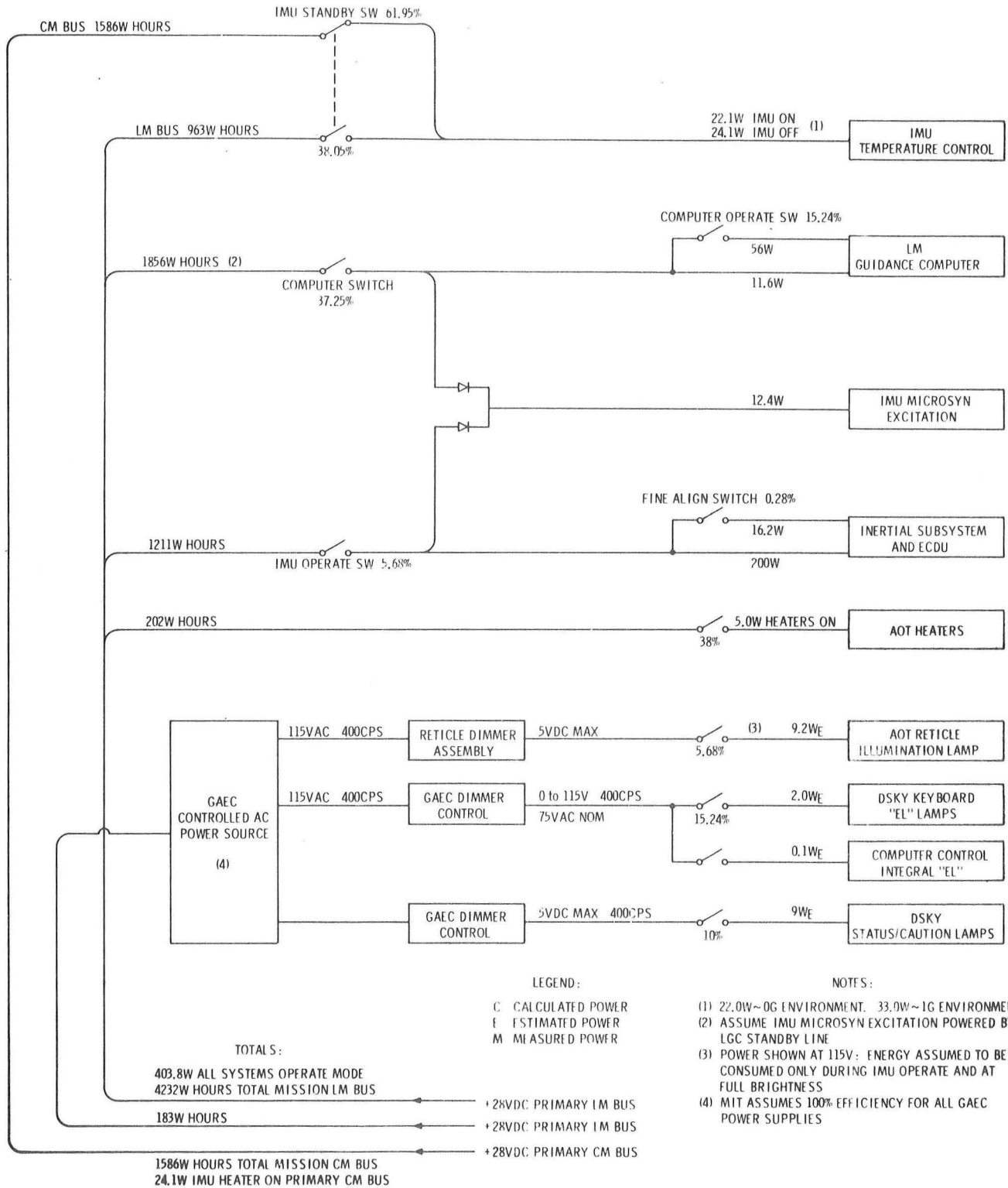


LUNAR MODULE GUIDANCE & NAVIGATION LOAD ON PRIMARY +28 VDC

BASED UPON 106.02 HOURS (4.42 DAY) LUNAR LANDING MISSION
DESIGN REFERENCE MISSION

STATUS OCTOBER 1967

REFERENCE GAEC REPORT - LED 540-12, 30 OCTOBER 1964
APOLLO MISSION PLANNING TASK FORCE



SECTION 5

GUIDANCE AND NAVIGATION SYSTEMS STATUS

The status of delivered G&N Systems are shown in tabular form. Table I shows the status of G&N Systems progressing from installation to final test at KSC.

Table II shows the configuration for major units comprising the G&N Systems assigned to LTA-8 and subsequent LM Vehicles at GAEC.

Table III shows the configuration for major units comprising the G&N Systems assigned to CSM-20 and subsequent Command Modules at NAR.

Table IV shows the configuration for major units comprising the G&N Systems at KSC.

TABLE 1

LOCATION									
OPERATIONS	GAEC		NAR				KSC		
	LM-2 608	LM-3 605	CSM98 2TV-1 202	CSM-101 204	CSM-102 205	CSM-103 206	CSM-17 122	CSM-20 502	LM - 1 603
INSTALLATION	X	X					X	X	X
SUBSYSTEM CHECKOUT S/C							X	X	X
INTEGRATED TEST S/C							X	X	X
COMPLETE TESTING AT KSC							X		

NOTE: CSM-17 completed testing and was successfully launched in November.

DATE: December 1967

TABLE II

LM G&N SYSTEM CONFIGURATIONS

1 December 1967

S / C	LM - 2		LM - 3		LM - 4	
COMPONENT NOMENCLATURE	System 608		System 605		System 606	
	Part Number	S/N	Part Number	S/N	Part Number	S/N
AGC	2003993-021	26	2003993-031	32		
DSKY	2003994-011	46	2003994-011	49		
IMU	2018601-111	18	2018601-111	12		
ECDU	2007222-221	10	2007222-221	24		
AOT	6011000-071	17	6011000-071	18		

NOTE: Listing will be revised if major units are changed. Explanatory notes will describe reason for changes.

TABLE III

CSM G&N SYSTEM CONFIGURATION AT NAR

S/C COMPONENT NOMEN- CLATURE	CSM-20 System 123		CSM-98 System 202		CSM-101 System 204		CSM - 102 System 205	
	Part No.	S/N	Part No.	S/N	Part No.	S/N	Part No.	S/N
AGC								
DSKY (Main)								
DSKY (Nav.)								
IMU								
CDU								
OPTICS								

DATE: December 1967

NOTE: Listing will be revised if major units are changed. Explanatory notes will describe reason for change.

The following changes affect the previous listing:

1. Blank spaces in Table above indicate Systems removed from Spacecraft. Upon reinstallation, configuration will be updated.

TABLE IV

G&N SYSTEM CONFIGURATION AT KSC

S/C	20		LM-1	
COMPONENT NOMENCLATURE	System 123		System 603	
	Part No.	S/N	Part No.	S/N
AGC	1003700-071	13	2003993-011	30
DSKY (Main)	1003563-051	9	2003994-011	37
DSKY (Navigation)	1003706-051	7	-----	--
IMU	1001500-111	8	2018601-111	6
CDU	1021304-031	6	2007222-171	12
OPTICS	2011000-23	9	6011000-021	9

DATE: December 1, 1967

NOTES: Listing will be revised if major units are changed. Explanatory notes will describe reason for change.

The following changes affect the previous listing:

LM-1, G&N System 603:

Replaced CDU 2007222-131, S/N 25 with 2007222-171, S/N 12, to replace Sprague Capacitors P/N 1010317-4, which exhibited shorts and opens.

S/C-17, G&N System 122:

System launched and returned to NAR.

SECTION 6

G & N SYSTEM TEST

A. System Test Laboratory

1. G & N 5

The AGC and OUA were operated for approximately 52.0 hours during October and November, 1967.

2. G & N 104

a. Program Tests

- (1) Conducted a 501 abort simulated flight utilizing an improved method for loading the R, V, T update.
- (2) Verified 501 FRT tapes;
#F04C017K00067-01
#F04C017K00068-01
#F04C017K00073-01 .
- (3) AS-502 support: Verified the abort simflite tape for S/C-20.
- (4) Provided AS-501 Mission support during Countdown.

b. Hardware Tests

- (1) Conducted emergency control temperature test simulating a failure in emergency control mode of operation. Test results are discussed in STG Memo #1075.
- (2) Investigations of abnormally high values of ADIAX (100 meru) were made, concluding that the X IRIG should be removed from the system. It is suspected that this failure is a direct result of gimbal runaway which was experienced during a low voltage transient test performed for NAR.
- (3) Conducted a coolant transient test simulating a GSE

refrigeration removal from the S/C evaporator prior to liftoff. Purpose was to measure time to reach the critical temperature limits for PSA Trays 2, 3, 4 and the AGC Interface. Results are covered in Thermal Memo #224.

- (4) Continued ADIA shift investigations.

3. G & N 200

a. Program Tests

- (1) The occurrence of alarm 1502 (Illegal use of flashing display - Abort) during Program P-52 was resolved by adding constraint into the GSOP.
- (2) While performing Program P-40 (SPS burn) it was found that bit 11 of Channel 12 was not being set by program in SUNDISK #266. This caused optics DAC to be still engaged and TVC signal can drive optics into stops if optics control is in CMC.
- (3) Level 5 program verification started on Revision 260 of SUNDISK was completed on Revision 265.
- (4) Change in Markrupt routine initiated in Revision 262 was found to have a problem. This was corrected in Revision 263. (Loc 10, 2035 was changed from 12001 to 12004).
- (5) There exist two problems which require further investigation; they are:
 - a. Inability to call up a monitor following Coarse Align of System. Occurred once, has not repeated.
 - b. CMC was dropping G&N Fine Align Test routine approximately 2 minutes after entering PIPA monitor routine. Reason unknown.
- (6) ACED performed a checkout of an Erasable ENDIDLE Routine. Results were satisfactory.

b. Hardware Tests

- (1) Considerable time was spent on checkout of tracker electronics. This ended with a successful demonstration

of tracker operation.

- (2) A verification of the method proposed to correct Y PIPA Scale Factor for Nav. Base tilt as proposed in AG: 439-67 was performed. Results will be written up in a separate report.

- (3) Failures

The X - gyro S/N 7A22 was replaced with S/N 7A114. The ADIA term of 7A22 showed large excursions.

Gimbal Servo Amp. module S/N 262 was found with resistor R-32 open. This was repaired and module was returned to PSA. Most probably cause was incorrect loading of the test point R-32 supplies.

Modulator and Loop Compensation module S/N 251 was replaced with S/N 1/ Module S/N 251 was not corrected for phase inversion in the tracker loop.

- (4) Modification

Anti-creep module S/N 251 was removed per ECP-590 for optics fix.

4. G & N 600

a. Program Tests

- (1) Verified test procedures for BURST 120 (LM-1) RCS and GTS Polarity Test.
- (2) Evaluated LR Program change to spot downlink updating while data is being read. Processed new Landing Radar Flight Tapes.
- (3) Determined cause of LM-1 Restarts during FCS testing as an erasable conflict with orbital integration. The abort condition of the first Restart (program alarm 1206 due to dual use of the of the keyboard) caused orbital integration to be activated, thereby destroying the FCS load. The two following initializations of FCS test resulted in Restarts due to the changed data.
- (4) Conducted a BURST 120 Simflight successfully. Obtained a pre-MP11 Erasable Memory dump for possible

simulation loads. Obtained a CRS trace of thrust commands during Mission Phase II.

- (5) Conducted a BURST 120 Simflight tests at 270⁰ azimuth for jet response recordings and time lines for LC-37 OCP's.
- (6) Commenced verification procedures with SUNDANCE 244 and 245. Concentrated mainly on Rendezvous Radar routines (P20).
- (7) Performed AOT Fine Alignment Test for GAEC personnel and corrected their procedures.

b. Hardware Tests

- (1) The CDU fine switching transient fix (new transistors and added resistors) was tested. The fix allowed few extraneous pulses. The fix is also required in the coarse module.
- (2) The IRIG preamplifier wiring modification is not effective at system level. Tests are being made to evaluate problem.
- (3) Ascent battery switchover tests were conducted. The fully charged battery transients (worst case) resulted in Restarts due to the low voltage (below 22 volts) incurred. Also gyrocompass went off due to extraneous PIPA pulses generated under the degraded low voltage condition. A full report is in process.
- (4) Modifications
Updated "A" and "B" Harnesses to Revision 19.
- (5) Further investigation of the IRIG Preamplifier noise problem indicates an interaction between preamps with added inductance. None of the proposed fixes (including ECP-0653) have helped with IMU 600.
- (6) Obtained may tape traces of CDU registers every 20ms for CDU transient tests.
- (7) Failures
Y Gyro 7A47 had a wheel failure. During ISS testing an

over-voltage of 55v did not run up the wheel. A contributing factor was gimbal runaway caused by incorrect servo phasing.

The floating insert in the IMU mounting fixture failed.

B. Field Operations

1. GAEC

- a. LM-2 (Mission AS 208) G & N System 608

Testing scheduled to begin again on 4 December 1967 with OCP 61014, Flight Control Checkout.

- b. LM-3 (Mission AS 503) G & N System 605

Vehicle demated; no further testing scheduled until 4 January 1968.

2. KSC

- a. LM-1 (Mission AS 206) G & N System 603

Vehicle has been mated and transported to LC-37.

- b. CM-17 (Mission AS 501) G & N System 122

Vehicle launched and G & N with capsule now at NAR.

- c. CM-20 (Mission AS 502) G & N System 123

S/C has arrived and is located in the MSOB.

3. MSC

- a. Provided software support to MSC. LTA-8 is in Thermal-Vacuum Chamber.

4. NAR

- a. CM-101 (Mission AS 205) G&N System 204

IMU replaced due to End Cap modification. Laboratory checkout completed and System made available for installation.

5. Edwards A. F. B.

- a. The Horizon Definition experiment has been installed into the X-15-1. Problem in coupling was found and corrected. Launching has been delayed due to heavy rains on dry lake bed.

C. Systems Engineering

1. Spacecraft Test Support

- a. The read and write pulse check portions of the Self Test have been programmed for E-Memory and are ready for checkout.
- b. Requirements were established for an E/BKCALL Program which will allow any routine which is normally called via BANKCALL to be called from erasable and for changes to the interpretive STORE command.
- c. A fix for potential problems in the UPLINK KKK Test was proposed and a memo distributed.
- d. Detailed training on the proper procedures for the AOT functional accuracy test and fine align test were provided to AC and KIC engineers. The tests were simulated using the AOT on the MIT roof and the LM System in the STG Lab. Errors were found in the GAEC OCP. The requirement for use of air calibration numbers was also pointed out. These tests are to be performed at GAEC and KSC.
- e. Digital simulations of the LM-1 DAP polarity tests were performed.
- f. The DAP Polarity Test for LM-1 has been successfully run in the Lab and further Polarity Tests are being prepared. Digital Simulations of the tests are being made. Information on the Radar Program operation was supplied to KSC.
- g. A memo providing a technical input for a Flight Test Planning Meeting at MSC was prepared.

2. Analysis and Test

- a. Preliminary results from a study of the LM Battery Transient Tests indicate that the observed gimbal motion is due to erroneous PIPA outputs. The possible effects of bits being in the Uplink register prior to sending an Uplink transmission was studied and a memo (STG #1071) issued.
- b. The preparation of plans for testing of the auxiliary memory in the STG Lab continued. The sighting geometry problem for the star tracked Horizon Photometer experiment is being studied.

- c. The testing of the SUNDISK Programs Revision 265 in the STG Lab on the Block II System was completed. There are approximately 60 of these tests and the documentation of the results have been submitted. The effort on SUNDISK should now be completed unless further revisions are made requiring reruns of some tests.
 - d. The effort in this area is now shifting to testing the SUNDANCE LM Program in the System Test Lab with the LM System. A preliminary draft of a plan for this testing has been completed. Radar Program Tests using the Radar Simulation will be included, and testing of the AGS initialization is being studied.
3. Star Tracker - Horizon Photometer Flight Experiment M-439
- a. The Star/Horizon Simulator was taken to KIC and calibrated. The Star Tracker was checked out in the STG Lab and found to work. STG Memo 1068 was prepared giving the geometrical constraints and equipment operating procedures for this experiment.
4. KSC CHECKOUT
- a. System Test Program (P07) of the SUNDISK Program Assembly (Rev. 260) was verified per the KSC Process Specification in the G & N Lab.
 - b. LM RCS DAP and GTS Polarity Tests were verified in the G&N Lab using the SUNBURST Program Assimby (Rev. 120).
 - c. Block II CSM, LM and Block I CSM OCP's and Test and Check-out Plans were reviewed.
 - d. The following K-START Tapes were shipped to KSC:
 - F04C020-K00078-00, 502 Abort Simflight
 - F06L001-K00067-00, LM-1 Erasable Launch Load
 - F06L001-K00068-00, LM-1 Erasable Mission Load
 - F06L001-K00078-00, LM-1 Simflight
 - e. AG: 439-67 was written and transmitted to AC Electronics requesting additional testing be added to the IMU Performance Test section of the BlockII CSM Process Specification.
 - f. ND1002348, Revision B, Block II CSM Process Specification was reviewed and corrected. The corrections were transmitted to AC Electronics for incorporation.

- g. Submitted two card decks for S/C-020 K-START Tapes:
F04C020-K00012-00, AGC E-Memory Zeroing
F04C020-K00020-00, AGC Alarms and Interrupts Test
- h. Reviewed Block I, Block II, and LM OCP's and Test and Check-out Plans.
- i. Coordinated S/C-020 (502) K-START Tape schedule.

D. Test Equipment

- 1. 16 PM PIP Test Console installed in Houston on schedule.
- 2. Work is progressing on the ACG&N test equipment. Station has been fired up, minus some of the automatic monitoring equipment.
- 3. Apollo Mainline

Retrofit Kit drawing for the CTS and Buffer Box have been reviewed. Changes included fixes for noise (restart) problems, DSKY entry record capability, inhibition of program alarm indications, and priority of alarm indication thus increasing diagnostic capability.

Work is progressing on a jet firing monitor for LM and a rework of the Block II monitor. Also on an overnight programable downlink recorder and a dump protection circuit to protect the Block II System from Gimbal Runaway.

E. Mission Test Programming

- 1. SUNDISK

Completed formal verification documentation for P01.1-P01.5 - Gyro-compass.

- 2. COLOSSUS and SUNDANCE

Investigation of feasibility and requirements for further utilization of erasable memory for system test and prelaunch alignment programs. Results published in STG Memos #1073 and 1074.

The plan for SUNDANCE testing was completed and distributed. Preliminary runs of radar tests have been started. STG Memo 1087 describing the final version of the SUNDISK Alarms was prepared. Tests of certain SUNDISK Programs were rerun.

SECTION 7

G & N COMPUTER STATUS

A. Analysis Facility

1. Design Analysis

Tests were performed on the effects of inadvertently applying a large voltage into the ACE BIAS lines of the AGC. Due to limiting in the AGC power supplies the worst failures encountered were parity failures. (The voltage fail detection circuitry within the AGC was inhibited during these tests.) Further analysis indicates that no component failures will be encountered unless the condition persists long enough for the AGC to overheat.

No other analysis was performed during this period. Testing will resume when Monitor S/N 6 is completed.

2. Field Support

In addition to assisting field site personnel in analyzing restarts and procedural problems, work was done in processing data recorded by the AGC Monitors. Tapes recorded by the Monitors can now be processed by one of several programs on the H1800 computer to aid in the analysis of system problems.

3. Miscellaneous AGC Related Activity

a. New Monitors

Monitor S/N 5 has been delivered to the STG Lab. Wirewrap plates for S/N 6 are at Gardner Denver for wirewrapping -- they should be back around the middle of December. Some problems are still being encountered with the memory units -- they are being ironed out with the vendor.

b. Restart Monitor (Channel 77 Alarm Box)

A prototype Restart Monitor was checked out with an AGC, and repairability of the module was demonstrated by replacing one of the flat pack assemblies. Purchase Orders for components for the six "production" units have been sent to the vendors. A test fixture has been designed and is in the fabrication process.

Procedures for "sell-off" testing have been worked out.

c. Portable CRS (Portafam)

Still looking for a suitable tape transport for the Portafam.

Study and design of the AGC interface, tape, and control electronics is in progress.

d. Routine Maintenance

Routine maintenance of AGC's and support equipment in use in the STG Lab and hybrid simulation facilities was performed.

B. Components

1. 6321 & 6394 Au Ball Bond Failures

Later lots of Philco SCD 1006321 integrated circuits have exhibited intermittent open bond failures during and after screen and burn-in. These failures are characterized by notch initiated cracking between the gold rich phases of the gold-aluminum eutectic.

Autonetics has performed extensive studies of this identical failure mode and directions for corrective action were pointed out. Philco, when performing matrix studies for determining contributing variables, did not consider the variables suggested by Autonetics.

In D. D. Memo #389, MIT/IL made recommendations for areas of investigation, particularly screening. To date, there has been no response from the vendor. The most worrisome aspect of the failure mode is a time dependence coupled with intermittency. An open bond can be "closed" by as little voltage as 2V, so that ordinary testing can temporarily heal the failure.

2. X-Ray Screening of 6321 Flat Packs

In D. D. Memo #393, MIT/IL has set forth the potentials of X-Ray screening of SCD 1006321 and 1006394 flat packs for bent leads, poor seal, dense particles and poor die attach. MIT/IL has further suggested X-Ray methods for detecting lifted chip which was proven feasible by Raytheon. MIT/IL submitted a change to the flight specification incorporating X-Ray screening of flat packs.

3. E-Memory Diode Failures

Open CDC SCD 1006399 diodes in E-Memory modules have been detected. The cause was hypothesized to be either improper potting of the modules or faulty diodes because of poor button to stud and/or poor chip to stud contact. Later CDC diode lots have exhibited these poor

contacts due to poor dimensional control coupled by the thermal mismatches of the glass, studs and chip. Cracking of the diodes would exhibit the same symptoms. The following facts have illuminated the subject:

- a. All the diode failures have occurred only in E-Memory modules where it was found that improper potting was performed.
- b. There is no correlation of lots which generated module failures to lots which generated contact failures during screen and burn-in.
- c. As suggested by MIT, Raytheon potted diodes by; (a) using no protective coating under the hard potting, (b) using partial protective coating under the hard potting and, (c) using full protective coating under the hard potting. The results were 7/15 failures, no protective coating; 2/15 failures, partial protective coating; 0/15 failures, full protective coating.

4. 6323 1 Mil Al Wire Transistor Failures

Studies have been performed by MIT/IL to attempt to resolve the contradictory data concerning SCD 1006323 1 mil aluminum wedge bond failures. The findings and conclusions are to be reported in E-2218.

By two different measurement methods it was found that the thermal time constant of the chip is of the order of twenty to thirty seconds while the thermal time constant of the wire is approximately 0.4 sec. The heating of the wire is dominated by chip heating until DC currents in excess of 450 ma are passed through the wire. The burn-in failures at Raytheon and Motorola can be explained by heating due to the electro-thermal mechanism where the cycling time is in the order of minutes. However, the various life tests performed by Raytheon and MIT simulating use conditions show either no failures or induced failures. The module and field failures show no relation to the worst case current

and power application. It is therefore concluded that field and module failures of the 1 mil Al wedge bonded are not caused by fatiguing caused by wire motion, but by mechanical stresses or previously undetected intermittent failures.

5. 6310 PNP Transistor

The PNP transistor from Motorola was reported in the last monthly report to exhibit a new failure mode. To solve this problem, Raytheon submitted a purchase order to Fairchild for the 1006310 with a penalty clause for late delivery. In the first group of devices fabricated by Fairchild, the devices would not meet the 500 ma H_{fe} specification and Fairchild requested a relaxation in the specification. The transistors arrived at Raytheon on the delivery date and supposedly met the relaxed specifications. No test results from the Raytheon screen and burn-in facility are presently available.

6. DSKY Redesign

The redesign of the DSKY has been continuing and the mechanical design of the IDM headers was completed. This enabled the last of the critical parts procurements, the IDM header. An indicator module was received from Pin-Lite and a first prototype indicator module was received from Tung-Sol. The prototype from Tung-Sol was an operating module which contained the complete optical section but did not have the final design on the header arrangement.

C. AGC Problems

1. AGC BL II Erasable Memory

MIT/IL letter AG 412-67 dated 25 Oct. 1967, enclosure "Electronic Packaging Memo #7-166" summarizes the Erasable Memory vibration problem.

D. ICD Problems

1. Clock Sync Transient

When LGC goes from standby to operate the clock sync interface signal goes out of spec. GAEC states that this will cause loss of telemetry for 1 second. NASA has indicated that this problem will be resolved procedurally. MIT/IL has submitted an ICD change request to GAEC. Problem still unresolved.

2. PGNS Caution Display

NASA has directed NAR and GAEC to delete the PGNS CAUTION interface wiring from the spacecraft. This change has been incorporated into NAA ICD. GAEC has not submitted an ICD change request yet.

3. VHF Ranging Unit

NASA has proposed a ranging capability for the CM-LM VHF voice link. The interface with NAA has been approved on ICDs. G&N harness changes are in preparation. AGC program has to be provided.

4. Noise on Uplink Line

In LM when turning power off the DCA or DUA units, noise is put on the uplink lines causing a possible uplink too fast alarm. It has been resolved by having an astronaut reset the program alarm and requiring the ground to clear the register at the beginning of an uplink transmission.

5. Computer Tray A Bulge

Computer Tray A bulges beyond ICD limits. ICD changes with NAA have resolved the problem for the CM. A satisfactory resolution has been reached for the LM however the ICD changes have not yet been prepared by GAEC.

6. Increased in DSKY dimension due to flammability changes have been documented by ICD change with NAR. GAEC has not yet responded to MIT's ICD change request.

SECTION 8

Apollo Guidance Computer Programming Summary for the Months of November & December

A. Mission AS-501 (Solarium) Unmanned CSM

MIT has received data which have allowed an evaluation of the performance achieved by the Apollo Guidance and Navigation System on its second unmanned flight.

The whole 8.5 hour trajectory was exceptionally close to that planned, including the 5 hours of on-board Guidance System controlled operations following two earth orbits and Saturn booster translunar injection simulation into a 10,000 mile high apogee trajectory.

The G & N System provided automatic on-board determination of position and velocity from the time of liftoff until the return to earth. It controlled numerous attitude maneuvers and two major burns of the Service Module engine. Twice the ground tracking system sent refined values of position and velocity up to the Guidance System. These were necessary to replace the on-board navigation measurements that are possible with the astronauts aboard. These updates were within the expected magnitudes.

The second Guidance controlled burn was for 4.5 minutes which provided the lunar return entry velocity test of 36,500 ft/sec. Ignition and turnoff signals were to be automatically generated onboard. Due to delay in telemetry signal transmission to the ground, the ground controller sent the turn-on command to the spacecraft just after this signal had already been generated automatically by the Guidance System. This ground controller action took the rocket turn off responsibility away from the onboard system. Actual turn off was commanded from the ground controller such that the rocket burned 13.5 seconds more than required for the planned entry test condition. The resulting 200 ft/sec. overspeed provided a more rigorous and successful atmospheric entry test both of the heat shield and for the on-board Guidance controlled entry trajectory which include a controlled skip and re-entry to the recovery point.

The last optical attitude reference check for the Guidance System occurred one day before liftoff and the system attitude reference remained under inertial sensing control from then on without further correction. Until liftoff the attitude reference was in a vertical-gyrocompass mode.

Total accumulated velocity change measured by the on-board accelerometers was over 70,000 ft/sec in this simulation. Kinetic energy per unit mass on hitting the atmosphere at entry was over twice that of the Gemini return from the earth orbit.

Guidance control of trajectory necessarily ended at 23,000 ft altitude when the drogue parachutes were deployed for final letdown in the sea 1,000 miles northwest of Hawaii. At this time the data reported the system had indicated guidance control to within 1.87 nautical miles of the programmed aim point in the on-board guidance system.

NASA presently plans to fly the AS-502 mission with the Solarium Program without changes.

MIT is planning to perform minor testing upon receipt of a AS502 Operational Trajectory to assure the capability of Solarium for the AS502 Mission and the generation of the erasable load.

B. Mission AS-204 (SUNBURST) Unmanned LM

The released Sunburst Program contains four restrictions. None of these restrictions are considered important by NASA/MSC and therefore no program changes are planned.

The remaining major tasks for MIT on Sunburst are:

Generation of the Erasable Load.

An end to end run that will verify compatibility of the erasable load and Burst 120.

Program support before and after the flight.

C. Mission AS- 205 (SUNDISK) Manned CSM

A First Article Configuration Inspection (FACI) Meeting was held at MIT/IL on October 4, 1967. Level 5 testing was begun after the FACI. Level 5 testing consisted of 160 test runs which took 6 weeks to complete. There were 103 program notes and discrepancies recorded during Level 4 and 5 testing. These items have been corrected by either program fixes, operational constraints or considered as being insignificant.

SUNDISK Revision 267 was released and sent to Raytheon on November 15, 1967; upon receipt of direction from NASA/MSC rope manufacturing will begin. Changes and retesting of the assembly is still being done under NASA Program Change Request (PCR) direction.

One ground rule adopted by NASA/MSC for the SUNDISK Program was that no LM rescue rendezvous would be done by the program. If necessary such a rendezvous would be by ground control and not G&N control when using the SUNDISK Program.

D. Mission AS-504 (SUNDANCE) Manned LM Earth Orbital

The SUNDANCE Program is presently in the level 3 testing phase which is scheduled for completion on 22 December 1967. FACI for SUNDANCE is scheduled for 15 March 1968.

MIT/IL is to provide GAEC with the erasable initialization and a Program Tape of the LM DAP on 1 December 1967. This tape will be used for testing and debugging on the GAEC simulator.

The major portions of the SUNDANCE Program Specification (GSOP Sections 4 and 5) are scheduled to be published in early December 1967.

A LM DAP review by NASA was held on 8 November 1967.

E. Mission AS-505 (LUMINARY) Manned LM Lunar Capability

The LUMINARY Program is presently in the level 2 testing stages with level 3 testing scheduled to start in late December 1967. Publication of the LUMINARY Program Specification (GSOP Section 4 and 5) are scheduled for mid - January 1968. FACI for LUMINARY is presented planned mid - July 1968.

F. Mission AS-505 (COLOSSUS) Manned CSM Lunar Capability

The COLOSSUS Program is presently in the level 2 testing stage with level 3 testing scheduled to start in early January 1968. Publication of the COLOSSUS Program Specification (GSOP Sections 4 and 5) are scheduled for late December 1967. FACI for COLOSSUS is presently planned for mid - June 1968.

The CSM DAP for COLOSSUS will be the same DAP that is presently in SUNDISK except for some minor changes and a change to R03 for loading of auto-pilot data. The VHF ranging capability has been added to the COLOSSUS GSOP Specification.

G. Program Change Control Procedure

During the reporting period considerable effort has been applied to the development and documentation of Program Specification Change Control Procedures. The objective being to promote orderly and timely development of Mission Programs through control of the configuration of software detailed specifications and the spacecraft computer programs.

COLOSSUS CMC PROGRAM (AS-504)

FIXED MEMORY ALLOCATION CHART (ESTIMATED)

I. Utility and Service Programs	
Interpreter, Single Precision Subroutines, Fixed-Fixed Constant Pool	2262
Executive	328
Waitlist, Longcall	240
Interrupt Lead Ins	52
Interbank Communication	88
T4RUPT	800
SXT Angle Monitor	75
Keyrupt-Uprupt	70
Downlink Program and 5 Lists	500
Fresh Start and Restart	420
Alarm and Abort	63
Delayjob	30
Restart Routine and Tables	400
Phase Table Maintenance	183
Pinball Program and Noun Tables	3000
Displays, Priolarm	700
Program Select (V37, P00, R00)	300
Self Check	310
Extended Verbs	550
RTBOPCodes	200
SXTMARK	353
IMU Mode Switching	580
IMU Compensation	250
LGC Startup (P05)	57
LGC Power Down (P06)	63
IMU Status Check	30
Systems Test (P07)	650
Interpretive Constants	29
Flagup, Flagdown	31
DAP Data Load (R03)	29
End Bank Markers	36
TOTAL UTILITY AND SERVICE PROGRAMS	12679

II. Autopilot and Maneuver Programs Digital Autopilot	
Entry DAP	850
CSM DAP	3421
Inertia Calc	100
Stroke Test	79
KALCMANU	710
Attitude Maneuver (R60)	60
Crew Defined Maneuver (R62)	16
Vecpoint	130
Rendezvous Final Attitude (R63)	30
Middle Gimbal Display	75
CM Body Attitude	200
TOTAL AUTOPILOT AND MANEUVER PROGRAMS	5671
III. Basic Math Routines	
Inflight Alignment Routines	287
Powered Flight Subroutines	156
CSM Geometry	210
Time of Free Fall	300
Conic Subroutines	1050
Orbital Integration	1400
PERIAPO	100
Lattitude, Longitude, Altitude	170
Initial Velocity	175
Lunar and Solar Ephemeris	75
Planetary Inertial Orientation	280
TOTAL BASIC MATH ROUTINES	4203
IV. Targeting Routines	
Transfer Phase Initiation Search	320
Return to Earth	1200
TOTAL TARGETING ROUTINES	1520
V. Navigation Routines	
Measurement Incorporation	350
Preferred Tracking Attitude (R61)	310
Lunar Orbit Navigation	750
Lunar Landmark Selection (R35)	190
Rendezvous Tracking Sighting Mark & Backup (R21, R23)	90
Rendezvous Tracking Data Processing & Backup (R22, R24)	400
Landmark Table	150
Cislunar Navigation	330
TOTAL NAVIGATION ROUTINES	2570

VI. Powered Guidance Routines	
Servicer	500
Desired Thrust Direction (S40. 1, S40. 2, 3)	350
Cross Product Steering (S40. 8)	140
VG Calculation (S40. 9)	100
Time of Burn Calculation (S40. 13)	80
Initial VG (S41. 1)	20
Entry Guidance	1200
TOTAL POWERED GUIDANCE ROUTINES	2390
VII. Alignment Routines	
Coarse Align (R50)	75
Fine Align (R51)	90
Auto Optics (R52)	155
Sighting Mark (R53)	50
Star Data Test (R54)	65
Gyro Torquing (R55)	40
Pick-A-Pair	125
Star Catalog	223
Alternate LOS Sighting Mark (R56)	54
Optics Calibration (R57)	50
TOTAL ALIGNMENT ROUTINES	927
VIII. Miscellaneous Programs and Routines	
P27 - Update Program	320
R36 - Rendezvous Out of Plane Display	120
P30 - External Delta V Prethrust	250
P31 - General Lambert Maneuver	120
R05 - S Band Antenna Display	85
R30 - Orbit Parameter Display	115
R31-R34 Rendezvous Parameter Display Routine 1 & 2	100
R32 - Target Delta V	100
R33 - CMC/LGC Clock Synchronization	24
TOTAL MISCELLANEOUS PROGRAMS AND ROUTINES	1234
IX. Mission Control Programs	
P01 Prelaunch or Service Initialization	38
P02 Prelaunch or Service Gyrocompassing	397
P03 Optical Verification of Gyrocompassing	130
P11 Earth Orbit Insertion Monitor	380
P15 Translunar Injection	250

P17	TPI Search	150
P20	Rendezvous Navigation	160
P22	Orbital Navigation	100
P23	Cislunar Midcourse Navigation	100
P34, P74	TPI Prethrust	450
P35, P75	TPM Prethrust	100
P37	Return to Earth	250
P38, P78	SOR Prethrust	50
P39, P79	SOM Prethrust	50
P40	SPS Thrusting	560
P41	RCS Thrusting	150
P47	Thrust Monitor	100
P51, P53	IMU Orientation Determination & Backup	265
P52, P54	IMU Realign and Backup	260
P61	Maneuver to CM/SM Sep Attitude	320
P62	CM/SM Sep and Pre-Entry Maneuver	90
P63	Entry Initialization	25
P64	Post 0.05G	20
P65	Upcontrol	20
P66	Ballistic	20
P67	Final Phase	40
P77	LM TPI Search	10
TOTAL MISSION CONTROL PROGRAMS		4485
MIT PAD		1100
GRAND TOTAL		36779
REMAINING FIXED MEMORY		85

LUMINARY LGC PROGRAM

FIXED MEMORY ALLOCATION CHART (ESTIMATED)

I. Utility and Service Programs

Interpreter, Single Precision Subroutines, Fixed-Fixed Constant Pool	2262
Executive	328
Waitlist, Longcall	240
Interrupt Lead Ins	52
Interbank Communication	88
T4rupt (R10, R25)	850
Keyrupt-Uprupt	70
Downlink Program and 5 Lists	500
Fresh Start and Restart	420
Alarm and Abort	63
Delayjob	30
Restart Routine and Tables	350
Phase Table Maintenance	183
Pinball Program and Noun Tables	3000
Displays, Priolarm	700
Program Select Check (V37, P00, R00)	300
Self Check	310
Extended Verbs	600
RTB OP Codes	200
Radar Rupts	230
AOTMARK (R53)	381
Backup Marking (COAS)	50
IMU Mode Switching	580
IMU Compensation	270
LGC Startup (P05)	57
LGC Power Down (P06)	63
IMU Status Check	30
System Test (P07)	675
Interpretive Constants	29

Flagup, Flagdown	31
DAP Data Load (R03)	160
Radar Subroutines	710
End Bank Markers	36
TOTAL UTILITY AND SERVICE PROGRAMS	13848
II. Autopilot and Maneuver Programs	
Digital Autopilot	3250
KALCMANU	680
Attitude Maneuver (R60)	60
Crew Defined Maneuver (R62)	18
Vecpoint	130
Rendezvous Final Attitude (R63)	30
Ball Angle Display	82
Middle Gimbal Display	75
TOTAL AUTOPILOT AND MANEUVER PROGRAMS	4325
III. Basic Math Routines	
Inflight Alignment Routines	250
Powered Flight Subroutines	156
LM Geometry	96
Time of Free Fall	300
Conic Subroutines	1050
Orbital Integration	1400
PERIAPO	100
Latitude, Longitude, Altitude	170
Initial Velocity	175
Lunar and Solar Ephemeris	75
* Planetary Inertial Orientation	280
TOTAL BASIC MATH ROUTINES	4052
IV. Targeting Routines	
* Predicted Launch Time	650
Coelliptic Sequence Initiation	440
Constant Delta Altitude	300
TOTAL TARGETING ROUTINES	1390

V. Navigation Routines	
Measurement Incorporation	350
Preferred Tracking Attitude (R61)	50
Rendezvous Navigation (LSR22.3, RADARANG)	450
* Lunar Surface Navigation (LSR22.4)	100
RR Search, Designate and Read	650
(R21, R22, R23, R24, R29, LPS20.1, LPS20.2 LRS22.1, LRS22.2, LRS24.1, CALCXY)	
 TOTAL NAVIGATION ROUTINES	 1600
VI. Powered Guidance Routines	
Servicer (R12)	850
Desired Thrust Direction (S40.1, S40.2, 3)	230
Cross Product Steering (S40.8)	75
VG Calculation (S40.9)	100
Time of Burn Calculation (S40.13)	105
* Descent Guidance (R11, R13)	923
* Ascent Guidance	700
TRIMGIMB (S41.1, S40.6)	65
TOTAL POWERED GUIDANCE ROUTINES	3048
VII. Alignment Routines	
Coarse Align (R50)	75
Fine Align (R51)	80
Auto Optics (R52)	55
Star Data Test (R54)	56
Gyro Torquing (R55)	40
Pick-A-Pair (R56)	142
Star Catalog	223
TOTAL ALIGNMENT ROUTINES	671

VIII. Miscellaneous Programs and Routines

R47 - AGS Initialization	100
R36 - Rendezvous Out of Plane Display	120
P27 - Update Program	320
P30 - External Delta V prethrust	150
* P31 - General Lambert Maneuver	120
R04 - RR/LR Self Test	102
* R05 - S Band Antenna Display	105
* R29 - Rendezvous Radar Flight Designate	
R30 - Orbit Parameter Display	120
R31 - Rendezvous Parameter Display	90
R32 - Target Delta V	100
R33 - CMC/LGC Clock Synchronization	27
* R77 - Radar Spurious Return Test	
TOTAL MISCELLANEOUS PROGRAMS AND ROUTINES	1354

IX. Mission Control Programs

* P10-P11 Predicted Launch Time	200
* P12 Ascent Guidance	200
P20 Rendezvous Navigation	200
P21 Ground Track Determination	50
* P22 Lunar Surface Navigation	20
P25 Preferred Tracking Attitude	70
P32-P72 CSI Prethrust	70
P33-P73 CDH Prethrust	100
P34-P74 TPI Prethrust	460
P35-P75 TPM Prethrust	95
* P38-P78 SOR Prethrust	50
* P39-P79 SOM Prethrust	50
P40 DPS Thrust	900
P41 RCS Thrust	150
P42 APS Thrust	30
* P46 Separation Monitor	50
P47 Thrust Monitor	70
P51 IMU Orientation Determination	210
P52 IMU Realign	154
* P57 Lunar Surface Align	500

* P63	Landing Braking	200
* P64	Landing Approach	150
* P65	Landing (AUTO)	100
* P66	Landing (ROD)	100
* P67	Landing (Manual)	100
* P70	DPS Abort	100
* P71	APS Abort	100
	TOTAL MISSION CONTROL PROGRAMS	4479
	MIT PAD	1615
	GRAND TOTAL	36382
	REMAINING FIXED MEMORY	482

* - Indicates program and routines that will be omitted from the Earth Orbital LM Program (Sundance).

SECTION 9

"E" AND "R" NOTES PUBLISHED DURING THE REPORTING PERIOD

- E-2172 Cloud Obscuration of Apollo Landmarks Derived from Meteorological Satellite Observations, September 1967 (U)
- E-2185 Landing Radar/LGC Interface Experiments, Part II - Flight Test Data Package, September 1967 (U)
- E-1142 System Status Report (Rev. 53), October 1967 (U)

E-1142 (Rev. 54)

DISTRIBUTION LIST

Internal

M. Adams (MIT/GAEC)

R. Battin

P. Bowditch/F. Siraco

W. Coleman

E. Copps

R. Crisp

J. Dahlen

J.B. Feldman

J. Gilmore

Eldon Hall

T. Hemker

D. Hoag

F. Houston

L.B. Johnson

K. Greene

J. Kingston (letter of transmittal only)

A. Laats

L. Larson

J. Lawrence

J. Lawson

T.M. Lawton (MIT/MSC)

G. Mayo

R.C. Millard

John Miller

J.S. Miller

J. Nevins

R. Ragan

N. Sears

G. Silver (MIT/KSC)

W. Stameris

R. Weatherbee

R. Woodbury

Apollo Library (5)

MIT/IL Library (8)

E-1142 (Rev. 53)
DISTRIBUTION LIST

External:

C. Frazier (NASA/MSC EG44) (2)
NASA/RASPO (1)
AC Electronics (10)
Kollsman (10)
Raytheon (10)
Capt. Mark Jensen (AFSC/MIT) (1)
T. Gibson (NASA/MSC FS55) (2)

MSC: (30 + 1R)

National Aeronautics and Space Administration
Manned Spacecraft Center
Apollo Document Distribution Office (PA2)
Houston, Texas 77058

KSC:

NASA J. F. Kennedy Space Center (1R)
Technical Document Control Office, HB-23
Cape Kennedy, Florida

GAEC:

Grumman Aircraft Engineering Corporation (3 + 1R)
Data Operations and Services, Plant 25
Bethpage, Long Island, New York
Attn: Mr. E. Stern

NAR:

North American Rockwell, Inc. (18 + 1R)
Space and Information Systems Division
12214 Lakewood Boulevard
Downey, California
Attn: Apollo Data Requirements, 096-340
Bldg 3, CA 99

NAR RASPO:

NASA Resident Apollo Spacecraft Program Office (1)
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 32-21
AC Electronics Division of General Motors
Milwaukee 1, Wisconsin
Attn: Mr. W. Swingle

(1)

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

(1)

Mr. S. Schwartz
Department of Defense
DCASD, Garden City
605 Stewart Avenue
Garden City, L. I., N. Y.
Attn: Quality Assurance

(1)

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