APOLLO

GUIDANCE AND NAVIGATION

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E-1142
(Rev. 56)

SYSTEM STATUS REPORT

APRIL 1968

MIT INSTRUMENTATION LABORATORY
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E-1142

(Rev. 56)

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 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.

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.

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INTRODUCTION

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

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Section 4 - Electrical Power Requirements
Section 5 - Guidance and Navigation Systems Status
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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 1.1 and 1.2, respectively, present the weights of all CM Block II, and LM Guidance and Navigation operational flight hardware based upon the most current information. These tables offer a comparison of present component weight values with those listed in the last 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.

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 by an explanation for the change.

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

Block II CM: None

LM: None

TABLE 1.1 CURRENT WEIGHT STATUS OF BLOCK II COMMAND MODULE GN&C (LBS AT 1G.

Command Module GN&C Equipment	Status 2/68	Change	Status 4/68	Design Load Weight*
LOWER EQUIPMENT BAY				
CDU Assy	36.5 (M)	0.0	36.5 (M)	50.0
Optical Subsystem SXT and gearing SCT and gearing Optical Base and gearing APTPS and Dust Covers	55.7 (M)	0.0	55.7 (M)	150.0
NVB and Mounts	17.4 (M)	0.0	17.4 (M)	
Bellow Assy	10.7 (M)	0.0	10.7 (M)	
IMU	40.9 (M)	0.0	40.9 (M)	
Coolant Hoses (2)	1.0 (M)	0.0	1.0 (M)	
Power Servo Assy	49.4 (M)	0.0	49.4 (M)	58.0
PIPA Electronics Assy	8.5 (M)	0.0	8.5 (M)	12.0
G&N Interconnect Harness Group	25.5 (M)	0.0	25.5 (M)	40.0
AGC (with six rope modules & mag. trays)	70.1 (M)	0.0	70.1 (M)	80.0
Optical Shroud	3.3 (M)	0.0	3.3 (M)	4.5
Optical Eyepiece Storage Assy SXT Normal Relief Eyepiece SCT Normal Relief Eyepiece SCT Long Relief Eyepiece	13.6 (M)	0.0	13.6 (M)	15.0
G&N Indicator Control Panel	14.7 (M)	0.0	14.7 (M)	17.0
DSKY	17.8 (M)	0.0	17.8 (M)	25.0
Signal Conditioner Assy (Operational Flights)	5.8 (M)	0.0	5.8 (M)**	8.0

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TABLE 1.1 CURRENT WEIGHT STATUS OF BLOCK II COMMAND MODULE GN& C (LBS AT 1G) (CONT'D)

Command Module GN&C Equipment	Status 2/68	Change	Status 4/68	Design Load Weight*
MAIN PANEL AREA				
DSKY	17.8 (M)	0.0	17.8 (M)	25.0
LOOSE STORED ITEMS				
Horizontal Hand Holds (2)	0.3 (M)	0.0	0.3 (M)	1.0
TOTAL	389.0	0.0	389.0	----
The reported total weight for this month is 11.0 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.

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TABLE 1.2 CURRENT WEIGHT STATUS OF LM PGNCS (LBS AT 1G)

LM PGNCS Equipment	Status 2/68	Change	Status 4/68	Design Load Weight*
IMU	41.0 (M)	0.0	41.0 (M)	80.0
AOT (including eyepiece and bellows)	24.4 (E)	0.0	24.4 (E)	
NVB	5.2 (M)	0.0	5.2 (M)	
HARNESS "B" Supported by the NVB	0.6 (E)	0.0	0.6 (E)	
HARNESS "B" Supported by the PTA	0.8 (E)	0.0	0.8 (E)	21.0
HARNESS "B" Supported by the structure	3.1 (E)	0.0	3.1 (E)	
PTA	14.4 (M)	0.0	14.4 (M)	
HARNESS "A"	15.6 (M)	0.0	15.6 (M)	22.0
LGC (with six rope modules & mag. trays)	70.6 (E)	0.0	70.6 (M)	65.0
DSKY	17.8 (M)	0.0	17.8 (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	17.7 (M)	0.0	17.7 (M)	28.2
SCA (Operational Flights)	5.5 (M)	0.0	5.5 (M)	
TOTAL	255.8	0.0	255.8	----
The reported total weight for this month exceeds the 245.0 pounds total control weight by 10.8 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.

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SECTION 2

GLOSSARY AND SYSTEM DEFINITION

The description of what constitutes the MIT Guidance and Navigation equipment in 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 in Table 3.1. This table 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 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.

TABLE 3.1 G&N MISSION RELIABILITY ANALYSIS (FAILURE RATES EXPRESSED IN "FAILURES PER 10^6 HOURS"

MISSION		IMU Assembly ON/STBY	IMU Electronics (PSA) ON/STBY	Optics Assembly ON/OFF	Optics Electronics (PSA) ON/OFF	IMU CDU ON/STBY	Optics CDU ON/OFF	AGC ON/STBY	DSKY ON/OFF	D&C ON/OFF	Mission Reliability
AGE 123 FLIGHT 502 UNMANNED	OPER HRS	8.3 -	8.3 -	- -	- -	8.3 -	- -	8.3 -	8.3 -	8.3 -	.9933
	λ	195 -	224 -	- -	- -	111 -	- -	257 -	12 -	6 -	
C/M FLIGHT 503 MANNED	OPER HRS	31.3 208	31.3 208	14.2 225	14.2 225	31.3 208	31.3 208	31.3 208	31.3 208	31.3 208	.9626
	λ	129 10.2	110 6.3	94 -	77 -	155 -	91 -	235 60.5	2.3	2.3 -	
LM FLIGHT 503 MANNED	OPER HRS	8.4 120	8.4 -	8.4 -	8.4 -	8.4 -	8.4 -	8.4 -	8.4 -	8.4 -	.9923
	λ	129 1.6	110 -	38 -	1.33 -	155 -	112 -	235 -	110 -	1.2 -	
C/M FLIGHT 205	OPER HRS	76 190	76 190	20 -	20 -	76 -	20 -	9.5 170	9.5 -	76 -	.9315
	λ	129 10	110 6	94 -	77 -	155 -	91 -	235 61	2 -	2 -	
C/M DES. REF.	OPER HRS	13.8 55.6	13.8 55.6	9.1 60.3	9.1 60.3	13.8 55.6	13.8 55.6	13.8 55.6	13.8 55.6	13.8 55.6	.9540
	λ	129 10.2	110 6.3	94 -	77 -	155 -	91 -	235 60.5	2.3 -	2.3 -	
LM DES. REF.	OPER HRS	3.25 66.3	3.25 66.3	3.25 -	3.25 -	3.25 -	3.25 -	3.25 -	3.25 -	3.25 -	.9969
	λ	129 1.6	110 -	38 -	1.33 -	155 -	112 -	235 -	110	1.2 -	

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SYSTEM 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 diagrams 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.

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

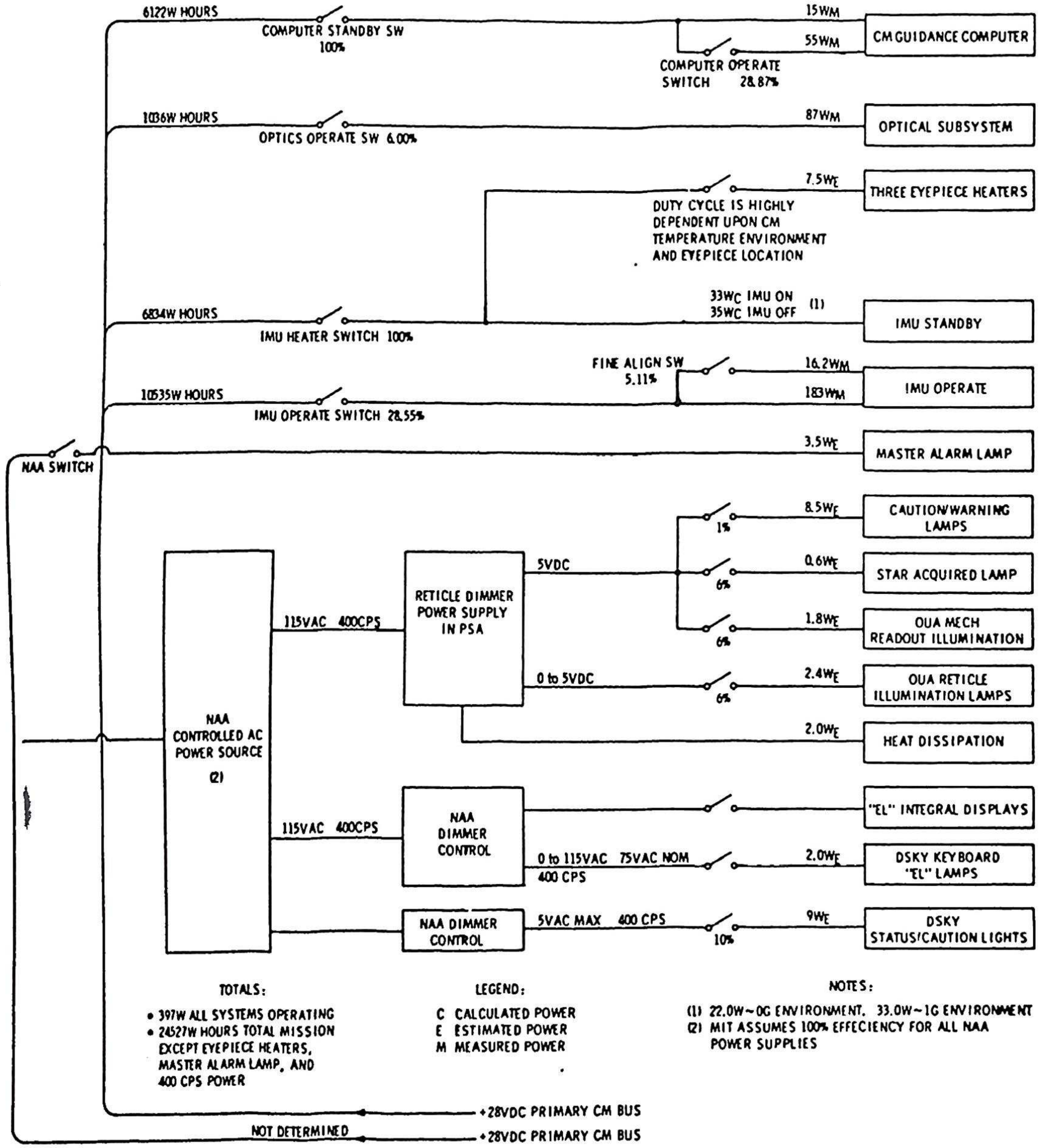
CM Block II	MH01-01327-216 "G&N Electrical Input Power" signed 15 July 1965
LM	LIS-390-10002 "PGNCS Prime Power Requirements and Characteristics" signed 30 July 1965.

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

BASED UPON 1985 HOURS 18.27 DAY) LUNAR ORBIT MISSION
DESIGN REFERENCE MISSION

STATUS OCTOBER 1967

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



TOTALS:

- 397W ALL SYSTEMS OPERATING
- 24527W HOURS TOTAL MISSION EXCEPT EYEPIECE HEATERS, MASTER ALARM LAMP, AND 400 CPS POWER

LEGEND:

C CALCULATED POWER
E ESTIMATED POWER
M MEASURED POWER

NOTES:

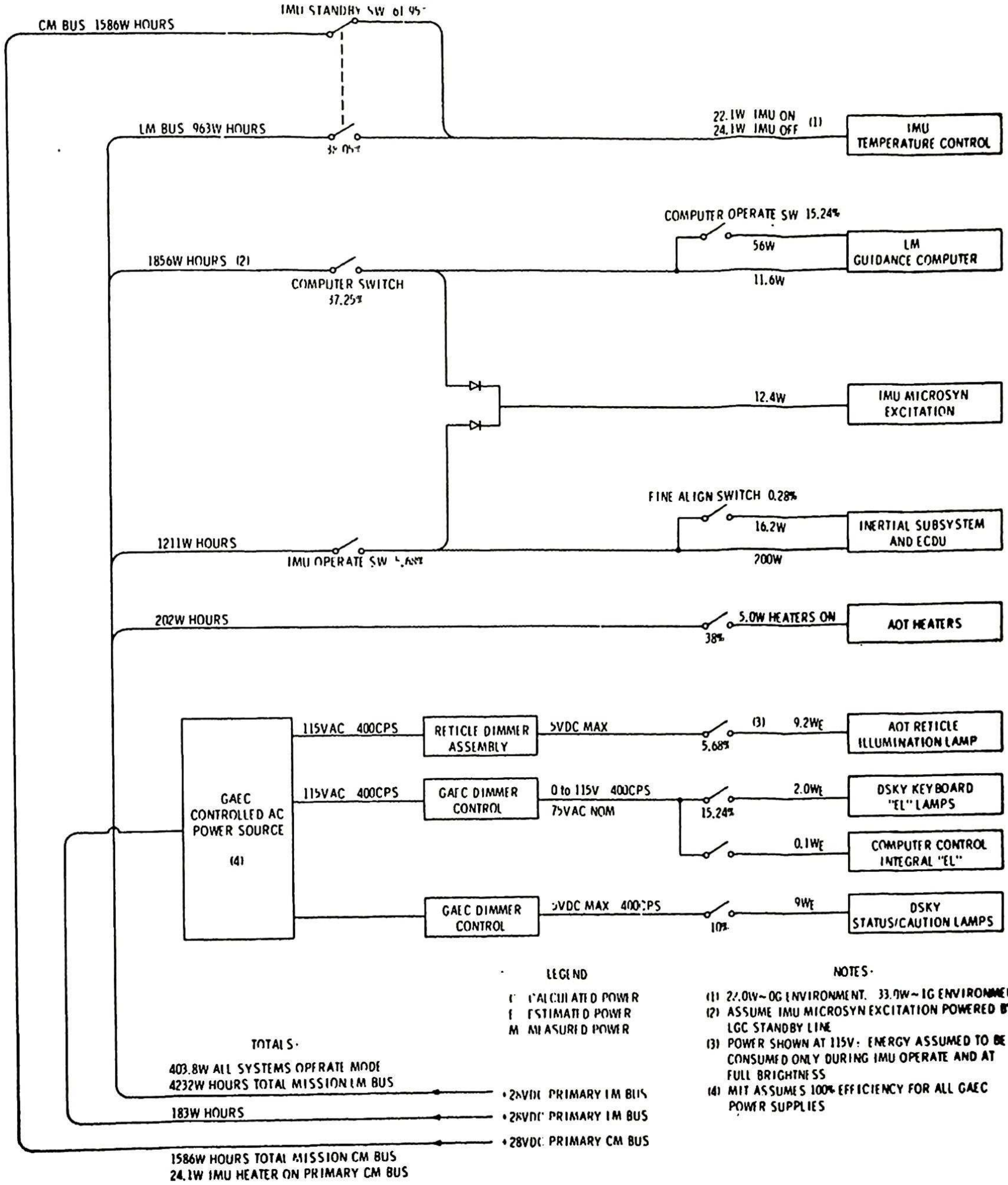
(1) 22.0W~0G ENVIRONMENT. 33.0W~1G ENVIRONMENT
(2) MIT ASSUMES 100% EFFECIENCY FOR ALL NAA POWER SUPPLIES

LUNAR MODULE GUIDANCE & NAVIGATION LOAD ON PRIMARY +28 VDC

BASED UPON 106.02 HOURS 14.42 DAY LUNAR LANDING MISSION
DESIGN REFERENCE MISSION

STATUS OCTOBER 1967

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



LEGEND

C CALCULATED POWER
E ESTIMATED POWER
M MEASURED POWER

NOTES:

(1) 22.0W ~ 0G ENVIRONMENT. 33.0W ~ 1G ENVIRONMENT
(2) ASSUME IMU MICROSYN EXCITATION POWERED BY LGC STANDBY LINE
(3) POWER SHOWN AT 115V: ENERGY ASSUMED TO BE CONSUMED ONLY DURING IMU OPERATE AND AT FULL BRIGHTNESS
(4) MIT ASSUMES 100% EFFICIENCY FOR ALL GAEC POWER SUPPLIES

SECTION 5

GUIDANCE AND NAVIGATION SYSTEMS STATUS

The status of delivered G&N Systems are shown in tabular form. Table 5.1 shows the status of G&N Systems progressing from installation to final test at KSC.

Table 5.2 shows the configuration for major units comprising the G&N Systems assigned to LM-2 and subsequent LM Vehicles at GAEC.

Table 5.3 shows the configuration for major units comprising the G&N Systems assigned to CM-98 and subsequent Command Modules at NAR.

Table 5.4 shows the configuration for major units comprising the G&N Systems at KSC.

TABLE 5.1 DELIVERED G&N SYSTEM STATUS

OPERATION	LOCATION			
	GAEC		NAR	KSC
	LM-2 System 608 LM-3 System 605 LM-4 System 606		CM-98 2TV-1 System 202 CM-101 System 204 CM-103 System 206	CM-020 System 123
INSTALLATION	X X X		X X	X
SUBSYSTEM CHECKOUT S/C	X X X		X X	X
INTEGRATED TEST S/C	X		X	X
COMPLETE TESTING AT KSC				X

DATE: 1 April 1968

TABLE 5.2 LM G&N SYSTEM CONFIGURATIONS

S/C	LM-2		LM-3		LM-4	
COMPONENT NOMENCLATURE	System 608 Part Number	S/N	System 605 Part Number	S/N	System 606 Part Number	S/N
LGC	2003993-031	28	2003993-031	32	2003993-031	31
DSKY	2003994-011	46	2003994-021	51	2003994-021	65
IMU	2018601-191	26	2018601-221	27	2018601-221	21
ECDU	2007222-221	10	2007222-221	24	2007222-221	18
AOT	6011000-071	17	6011000-072	18	6011000-081	16

DATE: 1 April 1968

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

1. LM-3, G&N System 605
   Replaced IMU 2018601-221, S/N 12 with 2018601-221, S/N 27. IMU modified to include new end cap changes per ECP 678.

TABLE 5.3 CM G&N SYSTEM CONFIGURATION AT NAR

S/C	CM-98		CM-101		CM-103	
COMPONENT NOMENCLATURE	System 202 Part Number	S/N	System 204 Part Number	S/N	System 208 Part Number	S/N
AGC	2003100-061	9	2003993-031	27		
DSKY (Main)	2003950-031	28	2003994-021	50		
DSKY (Navigation)	2003950-011	30	2003994-021	64		
IMU	2018699-031	5	2018601-201	8		
CDU	2010744-051	13	2007222-191	15		
OPTICS	2011000-062	23	2011000-071	24		

DATE: 1 April 1968

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

1. CM-98 (G&N System 202)
   Replaced DSKY (Main) 2003950-011, S/N 28 with 2003950-031, S/N 28 due to pushbutton and IL cover flammability fix.

2. CM-101 (G&N System 204)
   Replaced DSKY 2003994-021, S/N 41 with 2003994-021, S/N 64. CMC would not enter stand when "Proceed" button as actuated.

TABLE 5.4 G&N SYSTEM CONFIGURATION AT KSC

S/C	2	
COMPONENT NOMENCLATURE	System 123 Part Number	S/N
AGC	1003700-071	13
DSKY (Main)	1003563-051	9
DSKY (Navigation)	1003706-051	7
IMU	1001500-111	4
CDU	1021304-031	6
OPTICS	2011000-023	9

DATE: 1 April 1968

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

1. Replaced IMU 1001500-111, S/N 8 with 1001500-111, S/N 4. X-IRIG terminal board had a terminal with faulty staking and a cold solder joint.

SECTION 6

G&N SYSTEM TEST

SYSTEM TEST LABORATORY

A. G&N 5

No operating hours.

B. G&N 104

1. Program Tests

AS-502 Mission Support: Verified the following FRT K-START Tapes, including the FRT Simflight: #F04C020-K00068-00, #F04C020-K00067-00, #F04C020-K00073-00.

Verified FRT and G&N countdown demonstration K-START Tapes for S/C-20: Both sets are on metallized mylar tape.

FRT #F04C020-K00068 - Mission
#F04C020-K00067 - Launch
#F04C020-K00077 - Simflight

Countdown
#F04C020-K00068 - Mission
#F04C020-K00068 - Launch

Experimented with simulating an abort in the 502 Mission following a bad SPS1 burn. Can foul program after FDAI flag is taken down by loading an erasable location called LONG TIME (used in tasks).

2. Hardware Tests

The Z ternary current switch has been repaired but is still being bench tested. In the meantime, using a borrowed ternary current switch from G&N 5.

The proposed STG Memo describing the 0 VDC discrete for the 502 Mission was abandoned as Project SOLE (Scattered Optics Light Experiment) was scrubbed.

A hood temperature test was conducted on the IMU as a result of low IRIG temperature indication on the TMC (temperature monitor control panel). Concluded problem area was inside IMU. Rather than disassemble IMU, it was decided to modify the temperature alarm back-up module in tray 7 instead. This forces the TMC to read correct IRIG temperature.

Replaced X gyro S/N 2A30 with S/N 3A30. Determined that wheels stopped. Gyro was given to Inertial Subsystem Group for examination.

Total wheel hours - 6347 hours.

Conducted 502 simflight while generating a PIPA fail condition. There was no conflict except during an update. Program looks at MOD REG for P14 or P24. If not present, an update cannot be performed. One method of avoiding this is to load 40000 into an erasable location called OLD ERR. All G&N Failures will then be ignored by the computer.

Conducted a special accelerometer pulse measurements test whereby noise was injected in the 0 VDC and +28 VDC lines while at the same time opening the high side of the Z-accelerometer preamp output.

Results showed the loop to be inoperative with noise on the 0 VDC line of about 0.4 VRMS magnitude and a harmonic frequency of 3200 cps.

C. G&N 200

1. Program Tests

Continued checkout of SUNDISK Program; revision 282 is presently in use.

Verified new Gyro Compass Azimuth change routine as proposed for COLOSSUS.

Checkout of test program and procedure to verify RCS and TVC polarity was performed in support of Digital Simulation Group.

Continued checkout of Flight Simulation Test Program for SUNDISK.

Due to scheduling, no further work has been done on special PIPA test routine for determination of air bubbles. (Ref. P.R. 1 February 1968).

Problem with orbital integration routine in SUNDISK, Rev. 282. If both CSM and LM state vectors are not properly loaded a state vector overflow (Alarm 421) will occur and program will hang up in small alarm routine. Problem resolved by specifying that both state vectors be properly loaded.

Problem with Zero IMU CDU's routine. If zero CDU's is commanded more than once in four-second period, gimbals will jump. This can happen because the command V40N20 (Zero CDU's) is not wiped out by pushing ENTER (execute) and therefore accidently hitting ENTER twice is potentially possible.

Intended solution is procedural, in that gimbal angle monitor (V16N20) will be called up prior to zero CDU's (V40N20). This will then wipe out the zero command on the first ENTER.

Continued checkout of flight simulation program with variable azimuth.

Continued checkout of RCS and TVC polarity test for simulation group.

2. Hardware Tests

Problem with shaft angle overshoot and Trunnion CDU has not been cleared up due to scheduling problems. (Ref. P.R. 1 February 1968).

Performed Bus Voltage Transient Tests. Results will be written up in separate memo.

System was moved up to roof facility for checkout of tracker and photometer electronics. Results are written up in STG Memo 1119.

New problem with optics has come up. Telescope trunnion CMC drive is lost when photometer electronics is turned on. Reason under investigation.

Checkout of Downlink Digistore recording capability is in process. All problems are not yet resolved.

Investigated problems associated with CDU, FDAI, Att. SET, and ORDEAL switching circuits. It has been observed that the 11-1/4 degree bit in the MG CDU is reset at random times when switching ORDEAL into the loop. This has been traced to noise coupling from the IG cosine input into the CDU. Full report on this problem is in process.

Schedules have prevented further checkout of special PIPA test routine for determination of air bubbles (Ref. Progress Report, 1 February 1968).

Schedules have prevented further investigation of shaft overshoot trunnion CDU problem (Ref. Progress Report, 1 February 1968).

Problem associated with loss of Trunnion CMC drive when photometer electronics are turned on was traced to a wiring error in PSA (Ref. Progress Report, 1 March 1968).

Checkout of Downlink Digistore recording capability was completed. System is now ready for use.

3. Failures

Zero button on DSKY S/N RAY 14 failed. Removed DSKY for repair. Loan unit presently in use.

4. Modifications

Modified MSA and Quadrature Rejection Modules S/N HUG 255 and S/N HUG 260 were installed in CDU. Modules S/N HUG 255 and S/N HUG 203 were removed for modification.

D. G&N 600

1. Program Tests

System Test Verification Plan (informal) completed except for ICP. 3 and ICP. 4. These IMU compensation plans are awaiting the erasable AGS alignment segment.

A fixed memory version of the AGS alignment was satisfactorily tested.

The erasable IRIG Scale Factor and IMU Performance Test Programs appear to function properly. System data, on both SUNDANCE and AURORA, are being compiled for comparison.

To save turn-around time on testing erasable segments, the programs are being assembled and stored on digistore tape to be loaded directly through the CRS into E memory.

Simflight has exercised most SUNDANCE programs. P40 and P42 burns, however, are still marginal.

Continued checkout of SUNDANCE Program Revisions 263 to 282. STG Verification Tests, Level III, have been completed.

Erasable memory segments were tested. These included IMU Performance, IRIG Scale Factor, AGS Alignment and Self Test.

Supported Simflight and RCS Polarity procedure testing.

2. Failures

The inner gimbal ECL module in the CDU was replaced. A $\Delta\theta$ abort signal was not being reset.

The B harness was replaced due to an intermittent in the OG torque motor line.

The floating self-locking insert in the IMU mounting fixture was replaced.

The new CRS was swapped for the old CRS from the Hybrid Lab.

FIELD OPERATIONS

A. GAEC

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

Completed Phase III CARR milestone; shipping date unknown.

2. LM-3 (Mission AS 503) G&N System 605
Completed testing through OCP 32030; Individual System Test.

Completed OCP 61014, Flight Control Checkout, OCP 61015, pre-FEAT testing now in progress.

3. LM-4 (Mission AS 504) G&N System 606
Completed OCP 37027, G&N Fine Alignment.

B. KSC

1. CM-20 (Mission AS 502) G&N System 123
KSC testing completed. CM-20, AS 502 Mission scheduled for 4 April 1968.

C. MSC

Supported LM-1 mission anomalies.

Attended software DCR, S/C-101 and LM-3 hardware DCR. Inertial component temperature problem resolved. LTA-8 'dry runs' continuing; actual spacecraft testing to begin in middle April 1968. Attended Flight Director's Meeting concerning S/C-101 Mission.

D. NAR

1. CM-98 (2 TV-1 Thermal Vacuum) G&N System 202
System installed; completed OCP 6504, Individual Systems Test.
Completed Phase III CARR.

2. CM-101 (Mission AS 205) G&N System 204
System installed; completed OCP 6504, Individual Systems Test.

OCP-126, Combined System Test, has been completed. CDU 11-1/4 degree problem is being investigated.

3. CM-103, G&N System 208
System completed Phase II installation, Phase III installation is in progress.

4. CM-104 (Mission AS 504) G&N System 209
System completed Phase II installation, Phase III installation is in progress.

5. CM-106 (Mission AS 505) G&N 206
System awaiting Phase II installation.

E. ACED, Milwaukee

Drawings and specifications for new wheel builds have cleared CCB. All drawings for repair program have been released. Arranged for ACED personnel to visit MIT to observe clean room facilities and clean room practices.

Review of ACED flow documentation continuing. Representatives of the Gyro Group visited ACED on 26, 27, 28 March to observe wheel assembly procedures and techniques.

SYSTEM ENGINEERING

A. Spacecraft Test Support

STG Memo No. 1126 describing the E-Memory Read-Write Pulse Check Program and STG Memo No. 1124 describing the DSKY Check were prepared. A memo (STG No. 1110) describing the availability of Self-Test Programs was issued. The E-Memory Load Sum Program was coded and is being checked out.

A procedure to automatically update all erasable programs whenever a new version of the main AGC program is prepared was implemented. A new tape containing the updated program will be delivered with the digistore tape for the updated main program.

The investigation to develop diagnostic tests for PIPA and IRIG failures continued. Conclusive information did not result from the data obtained last month. The work is proceeding on a low-priority basis and progress will be slow until the DANCE test reporting discussed below is complete.

The preparation of the E-Memory AGSALIGN test continued. An E-Memory Program is scheduled to be available in March.

The E-Memory self-test program information was forwarded to AC by AG-131-68. The E-Memory sum-test program has been checked out (STG 1132). An extended self-test program is being developed.

Investigation of anomalies in the IRIG Scale Factor Test have continued. It appears that the program is working correctly but there are anomalies associated with time required for suspension. Further changes of the performance test were required and checkout is continuing. The checkout of the AGS align test also continued.

No progress was made this period on the special diagnostic tests for PIPA and IRIG failure.

The verification of procedures for checkout of AC-generated K-START Tapes was continued. Some assistance in debugging programs was provided to AC.

An optics drive failure report was reviewed with the Optics Group and it appears that MIT/IL should reactivate a previously proposed hardware modification. Until this can be accomplished, the optics should not be zeroed with large trunnion values. Instead, the trunnion should be first manually brought near zero.

B. Mission Program Testing

1. SUNDISK

The results of the SUNDISK testing were summarized at the SUNDISK CARR Meeting.

2. SUNDANCE

Considerable progress was made in the Lab testing of SUNDANCE. Detailed schedules were submitted to 23P by STG Memo No. 1121. The following table summarizes the status:

IMU Operations Tests	All Level III tests complete except for small point in the error monitor test. Documents being prepared.
AOT Alignment Tests	All Level III tests complete. Documentation being prepared.
System Extended Verbs	All Level III tests complete. Documentation being prepared.
System Test Programs	The performance test with changes to E-Memory was run. The nominal system test has not been run.
IMU Compensation Tests	Two of four of these have been done. Documentation is being prepared.
Alarm Tests	The testing is 90 percent complete.
Radar Tests	All of the tests have been tried, but some retesting may be required on 7 of the 12. Some bugs remain in the program. Documentation for one test is complete and the rest is being prepared.
Initialization Program Tests	One of these has been completed and documented. Another is awaiting the availability of the lab data-processing capability for SUNDANCE. The last involves the AGSALIGN test discussed above.

A memo, STG No. 1122, describing the requirements for the radar programs was issued. Considerable effort was also spent getting a working digital simulation of radar usage. Simulation and program problems were uncovered. STG Memo No. 1113, 1114, and 1117 describe some of this work.

Most of the Level III testing of SUNDANCE was completed. The following is the status:

IMU Operational Test	Completed
AOT Alignment Test	Completed
System Extended Verb	Completed
System Test Programs	IMU Performance Test being conducted.
IMU Compensation Tests	Two of four to be completed when AGS align E-Memory Program is available.
Alarm Test	Completed
Radar Tests	Completed but for one involving the processing of downlink.
Initialization Program Tests	AGS align test still being checked out. AGS initialization run, but waiting for data processing.

The 24 anomaly reports generated have been reviewed with the Mission Program Group and methods of problem resolution decided on. Some required changes have been made.

After the SUNDANCE FACI these tests will be repeated as part of the Level V tests.

STG Memo No. 1136 was prepared and published. This memorandum summarizes the operational requirements for the computer program SUNDISK with regard to interfaces with the CSM optics. The memo is also supplemental to the detailed description of optics - related computer routines found in STG Memo No. 1131.

IV. KSC CHECKOUT

A. Selloff of FRT (OCP-0028) K-START Tapes for S/C-020. (F04C020-K00067, F04C020-K00068, and F04C020-K00073).

B. Reviewed and corrected ND-1002348, Revision C (Block II CSM Process Specification).

C. Transmitted ND-1002348 corrections to NASA (also AC Electronics).

D. Developing IMU Performance Test and AGS State Vector Transfer Test K-START Tapes for LM-3 (SUNDANCE Program Assembly).

E. Reviewed RCS and TVC DAP Polarity Tests for use at KSC for S/C-101 (SUNDISK, Revision 282 Program Assembly) testing.

F. Results of review of Post-Installation Checkout Process Specification, ND-1002348, Revision C were published in STG Memo No. 1123.

G. STP 1, Nominal System Test, was conducted in the STG Lab. to verify compatibility between the SUNDANCE Program (Rev. 274) and the Post Installation Checkout Process Spec., ND-102349 (updated).

H. Reviewed and updated ND-1002349, Revision E - Post Installation Checkout Process Spec. for Apollo G&N System LM (KSC) Sent corrections to MSC.

I. Verified and sold off Launch Erasable Load and Misssion Erasable Load K-START Tapes (F04C020-K00067-01 through -07 and F04C020-K00068-01) for S/C-020 Launch (OCP-0007).

J. Preliminary IMU Performance Test (SUNDANCE) K-START Tape listings were sent to MIT/KSC and AC/Milwaukee on 27 March 1968.

K. Verified TVC Pitch Gimbal Polarity Test using SUNDISK Program Assembly, Revision 282.

L. A preliminary AGS Initialization (SUNDANCE) K-START Tape listing was sent to MIT/KSC on 28 March 1968.

V. TEST EQUIPMENT

A. Conversion of BB II GSE to Support 600F: Held in abeyance as per previous report pending availability of personnel.

B. Gyro Tumble Servo System: Equipment failures have been corrected. The equipment has been adjusted for proper operation. Procedures for adjustments and usage have been developed and are being documented.

C. Trace: NASA has authorized us to build one unit. ECP111 has been submitted to provide additional units for the Hybrid Facilities. Coroner Controls have been undergoing final redesign to satisfy programmer's needs. Sections of Trace Program have been started. The coroner memory has been specified and a requisition submitted.

D. Wheel Power Monitor: Work is continuing in this area to develop a small wheel power monitor for S/C usage.

E. CDU DAC Monitor: The cabling interfaces for the CDU DAC monitors have been designed and all required circuits breadboarded. Fabrication of the finished item should begin in April.

F. Miscellaneous Mainline Activity: Review of TDRR's, ICD's, and field problems continue on an as-required basis. Maintenance of GSE stations continues both on a regular basis and as required.

G. Uplink-Downlink Timer: Circuit design has been completed; fabrication has been initiated.

H. Glitch Detector Transients: Still under investigation.

I. Documentation: We are still working to complete documentation packages on existing hardware and on hardware currently in design. These projects include:

1. Hybrid I and Hybrid II Run List Printout
2. Gimbal Angle Readout Schematics and Description
3. Jet Monitor Panel Schematic and Description
4. CDU DAC Monitor
5. Uplink-Downlink Timer
6. Gyro Tumble Servo System

A test equipment documentation file is being set up which will contain schematics/ run lists/packaging and a detailed circuit description of all laboratory test equipment. This has pointed out the need for improved documentation in many areas, and efforts are being made to upgrade this information consistent with the time available and the laboratory needs. New equipment is being documented fully.

VII. MISCELLANEOUS REPORTS AND INVESTIGATIONS

A. Section 1 of the GSOP for COLOSSUS has been completed and submitted for review.

B. Supported checkout problem solution at KSC.

C. Investigated Block II IMU Performance Test result anomalies. Came to the conclusion that no anomalies exist. In every case the indicated malfunction turned out to be an actual malfunction.

D. TDRR #A17691 containing proposed changes to PS-2015000 was reviewed and returned for modification.

E. Two informally proposed changes, one to PS-2015000 and one to PS-6015000 were also reviewed. The proposed changes to PS-6015000 were erroneous and this change was reduced to correcting a typographical error in the PS. (change "degree" to "degree per sec" in Paragraph 3.1.6.2.2). The proposed additions of Signal Conditioner Requirements to PS-2015000 were approved pending receipt of the actual TDRR.

SECTION 7

G&N COMPUTER STATUS

DESIGN ANALYSIS & SUPPORT

A. Analysis Facility Activities

1. Feasibility of lowering prime power VFAIL level.

Tests were performed on AGC-CIM to determine the effects of allowing prime power (+28 volts) to drop to 20 volts before a VFAIL alarm occurs. Results show that the input can drop to 17 volts without affecting the AGC's 14 volt power supply. Because of delay between VFAIL and GOJAM (due to digital filtering) setting the VFAIL level at 20 volts should allow sufficient time for the computer to stop before regulation is lost in the 14 volt supply.

B. Field Support

Several problems and questions from field personnel were discussed. Among the more significant problems were:

1. Counter fail indications after a RESTART (see D.D. Memo 401 for details).

2. AGC WARNING indications after initial power-up (see D.D. Memo 403 for further details).

3. RESTART caused by too-rapid depression of the Error Reset key (causing a code 1206 abort).

C. Miscellaneous AGC Related Activity

1. Status of CRS S/N 5

Presently operating in the Hybrid Simulation facility. Three of the five memory units are updated to the latest configuration.

2. Status of CRS S/N 6

Logic modules are in final phase of checkout. All memory units should be updated and ready in approximately 1-1/2 months. CRS #6 should be ready in two months.

3. Block II AGC Status

a.	AGC-600M	Operating in hybrid simulation facility.
b.	AGC-200	Operating in C/N system in STG lab.
c.	AGC-200M	Presently in DD Group Lab. Module A7 is questionable.
d.	AGC-C1M	In DD Group Lab. Erasable memory, 2 interface modules, and 3 bit sticks are bad or questionable.
e.	AGC-PC2	Operating in hybrid simulation facility.
f.	AGC-C200	Operating in LM system in STG lab.

4. Block II DSKY Status

a.	AGC-600M	Comp Act lamp burned out. Also some bad relays.
b.	AGC-200M	Some bad relays.
c.	AGC-200M	Approximately 6 bad keys.
d.	AGC-C1M	Used as test unit for IL DSKY components.
e.	AGC-PC2	Some burned out status lamps.
f.	AGC-C200	Several bad keys.

COMPONENTS

A. X-Ray Screening of Flat Packs

There have been many failures during computer vibration due to contamination in the flat packs. A review of the history on all flight-type computers indicates up until recently there were only three. During the last couple of months there have been eight more confirmed with several more computer failures that are waiting analysis.

All flat packs are being X-rayed now in an attempt to screen these before final test. Previous to this action only those lots which failed the internal visual inspection were being subjected to an X-ray screen for contamination.

The important question that is still unanswered is whether computers should be recycled and revibrated using the new "Y"-axis vibration? This new vibration is assumed to be a more sensitive test for detecting flat pack contamination.

B. Ropes and Tape-Wound Cores

The problem of temperature-sensitive cores that was first detected in the ropes built for mission 206 is still a problem for the SUNDISK ropes. The first set of SUNDISK has two modules with cores that are temperature sensitive. The cause of the temperature sensitivity is not known as yet, but in order to screen for the problem at a lower assembly level than final rope sale a temperature test is being run before rope potting. The module can be repaired at this level of assembly.

There have been changes to the core specification and rope module purchase specification. These changes were reported to NASA via letter AG 103-68.

There is a proposed change in the method that is used to release program data to Raytheon. This was described to MSC via letter AG 143-68. In order to implement this change formally there will be changes required in the present rope module documentation. At the same time more adequate checking of the contents of the rope is being planned; that is, the data released from MIT will be checked for good parity and proper sum check and the test tape (checker tape) used at final sale of the rope module will be tested for good parity and sum check.

C. Review of a Multilayer Board Problem

An intensive review of what appeared to be a multilayer board problem was conducted. When all the facts were in from failure analysis, engineering tests and review of Raytheon test procedures it appears that there is no serious problem. The failures that were detected during logic module assembly were not indicative of a generic MLB failure mode which could go undetected during the module fabrication.

D. DSKY Lights

DSKY lights intensity is continuing to be a problem. There is a problem of measurement as well as intensity changes with time.

AGC PROBLEMS

A. Computers C-1 through C-12 and C-20 are being recycled to Ratheon. The rework is defined in ECP 0696. In addition the V-FAIL level detector will be changed from 22.3 ± 0.3 to 20.0 ± 0.3 volts. MIT/IL Letter AG 133-68 describes the impact of this change. This change may be cut into future production but unless all computers are recycled to Raytheon, there will be computers with the old (22.3 ± 0.3) V-FAIL level.

B. After almost one year of work and planning to provide diagnostic programs in the ropes used during sale, the La Mesh ropes, GSE, and JDC's are ready for use.

SECTION 8

APOLLO GUIDANCE COMPUTER PROGRAMMING SUMMARY

A. SOLARIUM - UNMANNED CSM

During the reporting period the SOLARIUM Program was tested and analyzed for support of Mission AS-502. Preliminary erasable loads have been generated and tested. Support has been provided to NASA/MSC in preparation for the AS-502 flight.

B. SUNDISK - Manned CSM (Earth Orbital)

The following activities were performed during the reporting period:

The SUNDISK Custom Acceptance Readiness Review (CARR) was held at NASA/MSC on 31 January 1968. SUNDISK Assembly Revision 282 was released for rope manufacturing.

The following items represent MIT/IL post-CARR Activities:

1. Rerun and document all post 267 tests on revision 282
2. Initialization data review and rerun of all level 5 tests
3. Mission sequence verification using the hybrid, digital and engineering simulators
4. Error runs to test:
   a. Navigation with a bad W-Matrix
   b. P40 restart during a de-orbit burn
5. Generation of a pad load and inflight recovery loads
6. Guidance System Operations Plan final review against the program
7. Verification of constants
8. Apollo Operations Handbook review and signoff
9. Mission rules and Flight Plan reviews.

The SUNDISK GSOP Section 3 (DAP) and the DAP verification test results were issued.

Section 5, Rev. 2, of the Guidance System Operations Plan relevant to guidance equations for program SUNDISK was released during this period.

An anomaly reporting procedure was adopted for post-FACI reporting of MIT/IL orginated anomalies. Anomalies generated by GAEC, NAA, MSC, etc, whether before or after FACI, should be reported on the anomaly forms. Thirteen of these reports have been initiated by MIT/IL.

C. SUNDANCE - Manned LM (Earth Orbital)

The SUNDANCE Program is in the final stages of Level 4 testing. The FACI for SUNDANCE is scheduled for 9 April 1968. This schedule change from 6 April to 9 April was the result of Program Change Requests.

Section 4 PGNCS Operational Modes, Revision 1, was issued during the reporting period.

Rough drafts of Section 3 DAP for SUNDANCE were sent to NASA/MSC for review in early March.

D. COLOSSUS - Manned CSM Lunar Capability

Level 4 tests for the COLOSSUS Program are scheduled to start early in April of 1968. FACI for COLOSSUS, previously scheduled for 3 July 1968, has been rescheduled for mid-July 1968 as a result of PCR activity.

Section 2 of the Guidance System Operations Plan relevant to data links for program COLOSSUS was released during this period.

E. LUMINARY - Manned LM Lunar Capability

Because the execution time in P64 is a problem, MIT/IL plans to reduce the DAP execution time to gain 4 percent.

The first LUMINARY assembly as distinct from SUNDANCE is planned for late March 1968. FACI for LUMINARY, previously scheduled for 24 July 1968, has been rescheduled for the latter part of September 1968 as a result for PCR activity.

Also during this period, the Lunar Landing Site Redesignation training tape and the Lunar Landing complete sequence training tape were sent to NASA/MSC. These tapes were run on the MIT/IL Hybrid computed during this period.

Section 4 of the Guidance System Operations Plan relevant to the PGNCS operational modes for program LUMINARY was released during this period.

TABLE 8.1

COLOSSUS CMC PROGRAM

FIXED MEMORY ALLOCATION CHART (ESTIMATED)

I. Utility and Service Programs	
Interpreter, Single Precision Subroutines, Fixed-Fixed Constant Pool	2225
Executive	340
Waitlist, Longcall	240
Interrupt Lead Ins	58
Interbank Communication	88
T4RUPT	794
SXT Angle Monitor	50
Keyrupt-Uprupt	68
Downlink Program and 5 Lists	425
Fresh Start and Restart	420
Alarm and Abort	63
Delayjob	30
Restart Routine and Tables	401
Phase Table Maintenance	183
Pinball Program and Noun Tables	2920
Displays, Priolarm	700
Program Select (V37, P00, R00)	300
Self Check	314
Extended Verbs	600
RTBOP Codes	200
SXTMARK	307
IMU Mode Switching	572
IMU Compensation	250
LGC Startup	30
LGC Power Down (P06)	48
IMU Status Check	17
Systems Test (P07)	630
Interpretive Constants	35
Flagup, Flagdown	63

GENTRAN	15
DAP Data Load (R03)	29
End Bank Markers	78
TOTAL UTILITY AND SERVICE PROGRAMS	12, 495

II. Autopilot and Maneuver Programs

Entry DAP	825
BOOST	65
RCS	1819
TVC	1671
TWINGIMB S40.6	68
TVNG	30
KALCMANU	715
Attitude Maneuver (R60)	85
Crew Defined Maneuver (R62)	11
Vecpoint	130
Rendezvous Final Attitude (R63)	40
Middle Gimbal Display	64
CM Body Attitude	195
TOTAL AUTOPILOT AND MANEUVER PROGRAMS	5718

III. Basic Math Routines

Inflight Alignment Routines	225
Powered Flight Subroutines	181
CSM Geometry	254
Time of Free Fall	268
Conic Subroutines	1094
Orbital Integration	1491
PERIAPO	78
Lattitude, Longitude, Altitude	159
Initial Velocity	175
Lunar and Solar Ephemeris	75
Planetary Inertial Orientation	204
TOTAL BASIC MATH ROUTINES	4204

IV. Targeting Routines

Transfer Phase Initiation Search	320
Central Angles Subroutine	46
TOTAL TARGETING ROUTINES	366

V. Navigation Routines	
Measurement Incorporation	333
Preferred Tracking Attitude (R61)	280
Lunar Landmark Selection (R35)	214
Rendezvous Tracking Sighting Mark & Backup (R21, R23)	75
Rendezvous Tracking Data Processing & Backup (R22, R24)	475
Landmark Table	150
TOTAL NAVIGATION ROUTINES	1527
VI. Powered Guidance Routines	
Servicer	450
Desired Thrust Direction (S40.1, S40.2, 3)	300
Cross Product Steering (S40.8)	140
VG Calculation (S40.9)	115
Time of Burn Calculation (S40.13)	80
Initial VG (S41.1)	20
Entry Guidance	1150
TOTAL POWERED GUIDANCE	2255
VII. Alignment Routines	
Coarse Align (R50)	80
Fine Align (R51)	125
Auto Optics (R52)	130
Sighting Mark (R53)	50
Star Data Test (R54)	55
Gyro Torquing (R55)	35
Pick-A-Pair	130
Star Catalog	223
Alternate LOS Sighting Mark (R56)	118
Optics Calibration (R57)	50
TOTAL ALIGNMENT ROUTINES	996
VIII. Miscellaneous Programs and Routines	
P27 - Update Program	306
R36 - Rendezvous Out of Plane Display	91
P30 - P31 EXT DELTA V & General Lambert Maneuver	305
R05 - S Band Antenna Display	85
R30 - Orbit Parameter Display	278
R31 - R34 Rendezvous Parameter Display Routine 1 & 2	170
R32 - Target Delta V	97
R33 - CMC/LGC Clock Synchronization	26
TOTAL MISCELLANEOUS PROGRAMS AND ROUTINES	1358

IX. Mission Control Programs

P01 - Prelaunch or Service Initialization	38
P02 - Prelaunch or Service Gyrocompassing	328
P03 - Optical Verification of Gyrocompassing	178
P11 - Earth Orbit Insertion Monitor	407
P17 - TPI Search	80
P20 - Rendezvous Navigation	150
P21 - Ground Track Determination	66
P22 - Orbital Navigation	1020
P23 - Cislunar Midcourse Navigation	560
P34, P74 TPI Prethrust P35, P75 TPM Prethrust	643
P37 - Return to Earth	1300
P38, P78 SOR Prethrust P39, P79 SOM Prethrust	237
P40 - SPS Thrusting P41 - RCS Thrusting	625
P47 - Thrust Monitor	50
P51, P53 IMU Orientation Determination & Backup	256
P52, P54 IMU Realign and Backup	380
P61 - Maneuver to CM/SM Sep Attitude	308
P62 - CM/SM Sep and Pre-Entry Maneuver	90
P63 - Entry Initialization	20
P64 - Post 0.05G	10
P65 - Upcontrol	50
P66 - Ballistic	15
P67 - Final Phase	40
P77 - LM TPI Search	1
TOTAL MISSION CONTROL PROGRAMS	6846
GRAND TOTAL	35765
REMAINING FIXED MEMORY	1099

TABLE 8.2

LUMINARY LGC PROGRAM

FIXED MEMORY ALLOCATION CHART (ESTIMATED)

I.	Utility and Service Programs	
	Interpreter, Single Precision Subroutines Fixed-Fixed Constant Pool	2200
	Executive	337
	Waitlist, Longcall	240
	Interrupt Lead Ins	58
	Interbank Communication	88
	T4rupt (R10, R25)	632
	Keyrupt-Uprupt	68
	Downlink Program and 5 Lists	425
	Fresh Start and Restart	426
	Alarm and Abort	63
	Delayjob	30
	Restart Routine and Tables	325
	Phase Table Maintenance	183
	Pinball Program and Noun Tables	2939
	Displays, Priolarm	700
	Program Select Check (V37, P00, R00)	310
	Self Check	314
	Extended Verbs	550
	RTB OP Codes	200
	Radar Rupts	190
	AOTMARK (R53)	430
	Backup Marking (COAS)	20
	IMU Mode Switching	572
	IMU Compensation	270
	LGC Startup	32
	LGC Power Down (P06)	48
	IMU Status Check	17
	System Test (P07)	632
	Interpretive Constants	35

Flagup, Flagdown	63
GENTRAN	15
DAP Data Load (R03)	150
Radar Subroutines	784
End Bank Markers	72
TOTAL UTILITY AND SERVICE PROGRAMS	13418

II. Autopilot and Maneuver Programs

Digital Autopilot	3250
KALCMANU	670
Find CDU W	401
Attitude Maneuver (R60)	124
Crew Defined Maneuver (R62)	11
Vecpoint	130
Rendezvous Final Attitude (R63)	67
Ball Angle Display	49
Middle Gimbal Display	64
TOTAL AUTOPILOT AND MANEUVER PROGRAMS	4766

III. Basic Math Routines

Inflight Alignment Routines	227
Powered Flight Subroutines	184
LM Geometry	99
Time of Free Fall	268
Conic Subroutines	1094
Orbital Integration	1497
PERIAPO	78
Latitude, Longitude, Altitude	159
Initial Velocity	175
Lunar and Solar Ephemeris	126
* Planetary Inertial Orientation	206
TOTAL BASIC MATH ROUTINES	4113

IV. Targeting Routines

Coelliptic Sequence Initiation Constant Delta Altitude	649
TOTAL TARGETING ROUTINES	649

V. Navigation Routines	
Measurement Incorporation	333
Preferred Tracking Attitude (R61)	103
Rendezvous Navigation (LSR22.3, RADARANG)	525
*Lunar Surface Navigation (LSR22.4)	
RR Search, Designate and Read (R21, R22, R23, R24, R29, LPS20.1, LPS20.2 LRS22.1, LRS22.2, LRS24.1, CALCXY)	650
TOTAL NAVIGATION ROUTINES	1611
VI. Powered Guidance Routines	
Servicer (R12)	1011
Desired Thrust Direction (S40.1, S40.2, 3)	121
Cross Product Steering (S40.8)	67
VG Calculation (S40.9)	103
Time of Burn Calculation (S40.13)	118
*Descent Guidance (R11, R13)	850
Throttle Logic	125
*Ascent Guidance	550
TRIMGIMB (S41.1, S40.6)	54
TOTAL POWERED GUIDANCE ROUTINES	2999
VII. Alignment Routines	
Coarse Align (R50)	61
Fine Align (R51)	103
Auto Optics (R52)	65
Star Data Test (R54)	41
Gyro Torquing (R55)	27
Pick-A-Pair (R56)	132
Lunar Surface Sighting Routine	215
Star Catalog	223
TOTAL ALIGNMENT ROUTINES	867
VIII. Miscellaneous Programs and Routines	
R47 - AGS Initialization	117
R36 - Rendezvous Out of Plane Display	91
P27 - Update Program	306
P30 - External Delta V Prethrust	98
*P31 - General Lambert Maneuver	150
R04 - RR/LR Self Test R77 - LR Spurious Return Test	145
*R05 - S Band Antenna Display	105

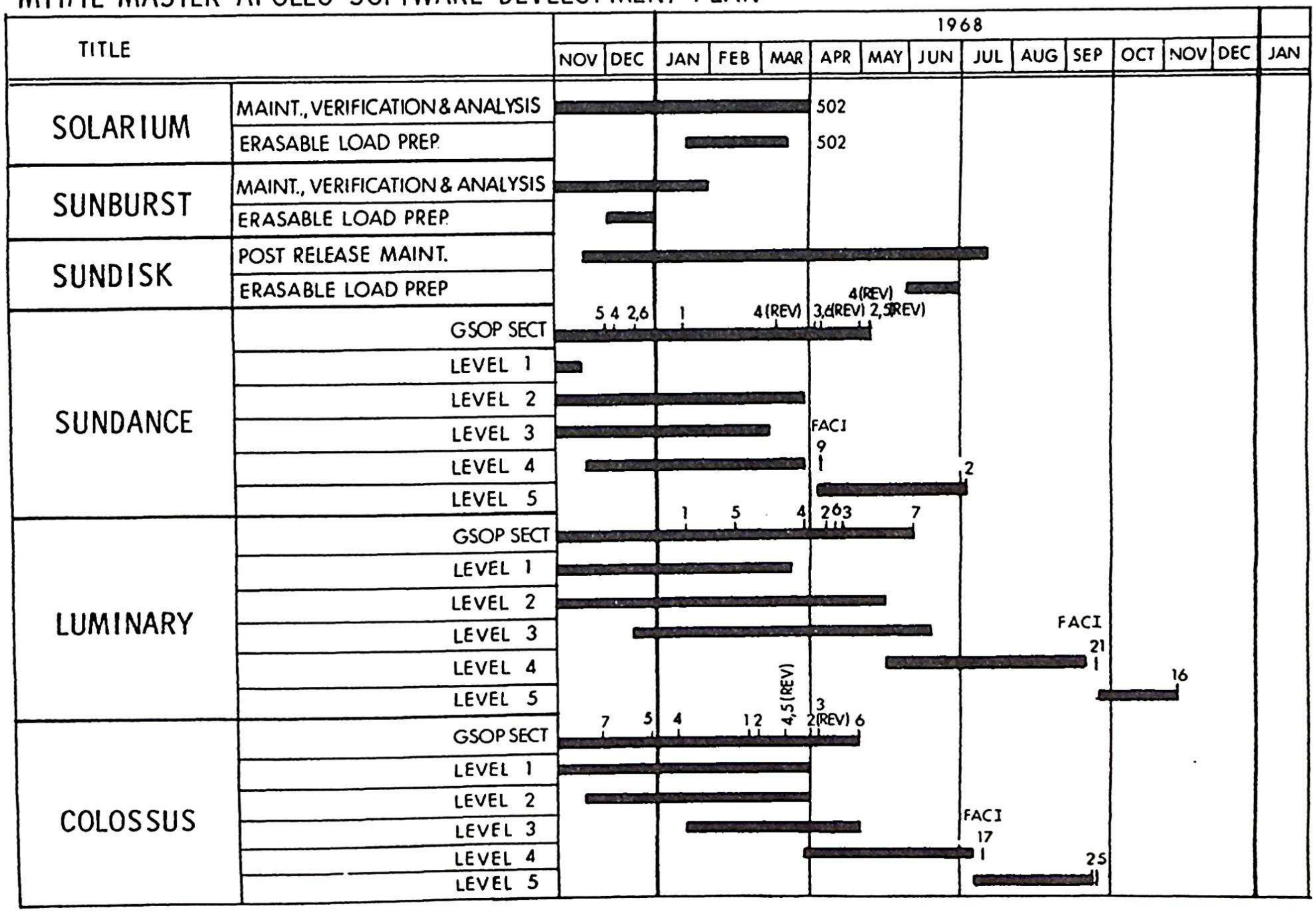
R29 - Rendezvous Radar Flight Designate	750
R30 - Orbit Parameter Display	278
R31 - Rendezvous Parameter Display	170
R32 - Target Delta V	97
R33 - CMC/LGC Clock Synchronization	26
R10 - Landing Analog Display Monitor	505
R11 - Abort Discretes Monitor	40
R13 - Auto Modes Monitor	50
TOTAL MISCELLANEOUS PROGRAMS AND ROUTINES	2428

IX. Mission Control Programs

P10-P11 Predicted Launch Time	450
P12 - Ascent Guidance	150
P20 - Rendezvous Navigation	427
P21 - Ground Track Determination	66
P22 - Lunar Surface Navigation	20
P25 - Preferred Tracking Attitude	54
P32-P72 CSI Prethrust	93
P33-P73 CDH Prethrust	136
P34-P74 TPI Prethrust	642
P38-P78 SOR Prethrust P39-P79 SOM Prethrust	227
P40 - DPS Thrust	980
P41 - RCS Thrust	78
P42 - APS Thrust	20
P47 - Thrust Monitor	63
P51 - IMU Orientation Determination	263
P52 - IMU Realign	164
P57 - Lunar Surface Align	600
P63 - Landing Braking	170
P64 - Landing Approach	50
P65 - Landing (AUTO) P66 - Landing (ROD) P67 - Landing (Manual)	130
P70 - DPS Abort	200
P71 - APS Abort	130
TOTAL MISSION CONTROL PROGRAMS	5113
GRAND TOTAL	35964
REMAINING FIXED MEMORY	900

MIT/IL MASTER APOLLO SOFTWARE DEVELOPMENT PLAN

DATE 4 / 1/68



SECTION 9

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

R-547 Guidance System Operations Plan for Manned CM Earth Orbital Missions Using Program Sundisk, Section 3, Rev. 1 & Rev. 2 CSM Digital Autopilots; Section 5, Rev. 2 Guidance Equations; April 1968 (U)

R-567 Guidance System Operations Plan for Manned LM Earth Orbital and Lunar Missions Using Program Luminary, Section 4 PGNCS Operational Modes; March 1968 (U)

R-577 Guidance System Operations Plan for Manned CM Earth Orbital and Lunar Landing Missions Using Program Colossus, Section 2 Data Links; Section 3 CSM Digital Autopilots; and Section 4, Rev. 1 Operational Modes; April 1968 (U)

E-2150 Guidance, Navigation and Control Block II Command and Service Module Functional Description and Operation Using Flight Program SUNDISK, April 1968 (U)

E-2252 Feldman, J., and R. Cooper, Inertial Components Reliability and Population Statisitics, March 1968 (U)

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