MASSACHUSETTS INSTITUTE OF TECHNOLOGY

APOLLO GUIDANCE, NAVIGATION AND CONTROL

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(Rev. 59)

SYSTEM STATUS REPORT

OCTOBER 1968

MIT INSTRUMENTATION LABORATORY
CAMBRIDGE 39, MASSACHUSETTS

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All requests for information should be addressed to the editor of the document, Richard Harlow, at the Instrumentation Laboratory.

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E-1142

(Rev. 59)

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
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.

All Tables, Graphs and Schematics are dated as of their last revision.

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.

NOTE
This is the last time this section will be reported. If there is a significant change in configuration weights, this section will be reinstated.

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

DATE: 1 April 1968

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 did not include the Optical Eyepiece Storage Assembly.

DATE: 1 April 1968

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.

DATE: 1 April 1968

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 EXPRESS IN "FAILURES PER 10^6 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	
CM	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	0.9840
DES REF	λ	129	10.2	110	6.3	94	-	77	-	155	-	91	-	235	60.5	2.3	-	2.3	-	
LM	OPER HRS	3.25	66.3	3.25	66.3	3.25	-	3.25	-	3.25	-	3.25	-	3.25	-	3.25	-	3.25	-	0.9969
DES REF	λ	129	1.6	110	-	38	-	1.33	-	155	-	112	-	235	-	110	-	1.2	-	

DATE: 1 October 1968

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 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.

NOTE

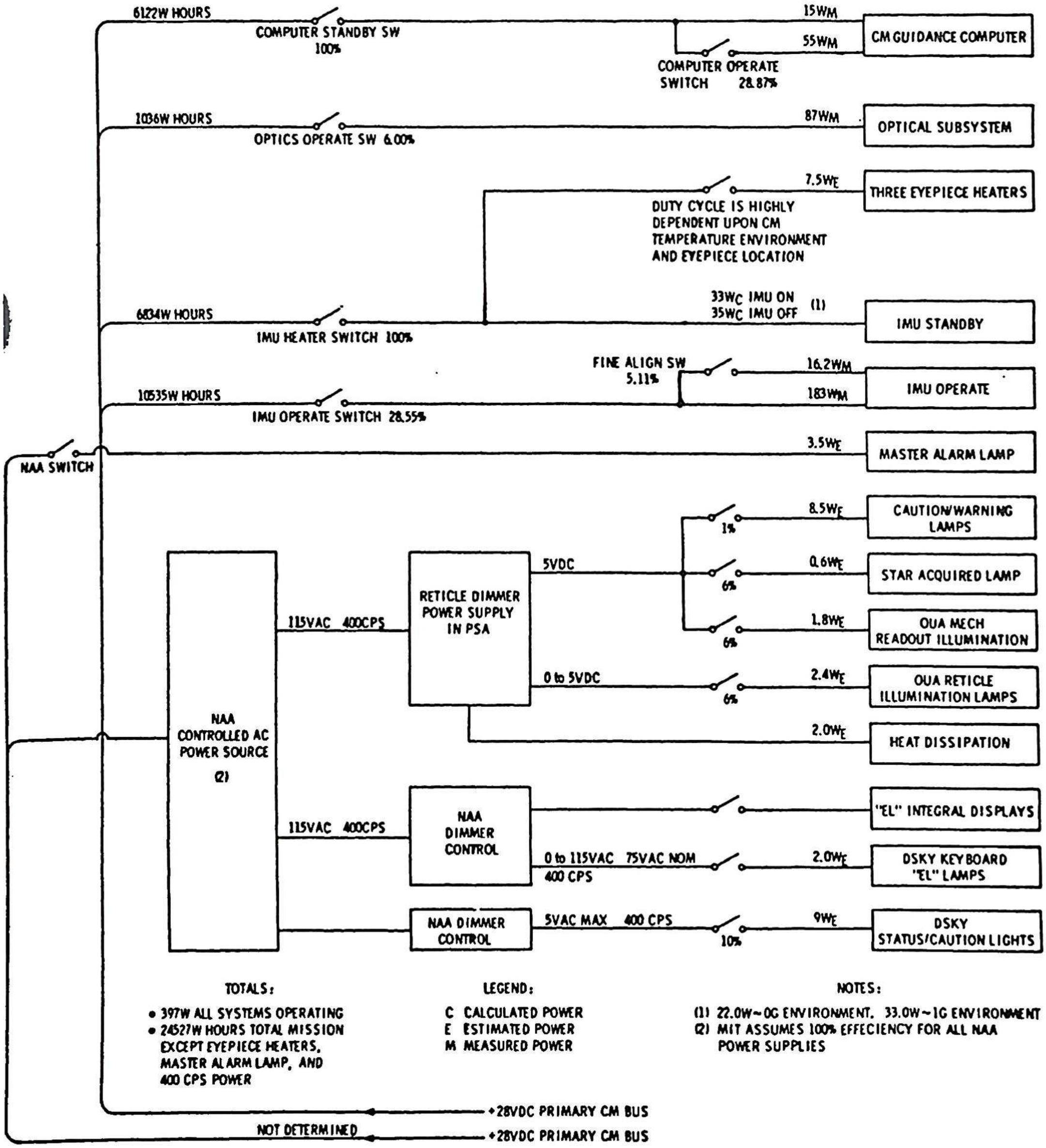
This is the last time this section will be reported. If there is a significant change in electrical power requirements, this section will be reinstated.

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



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:

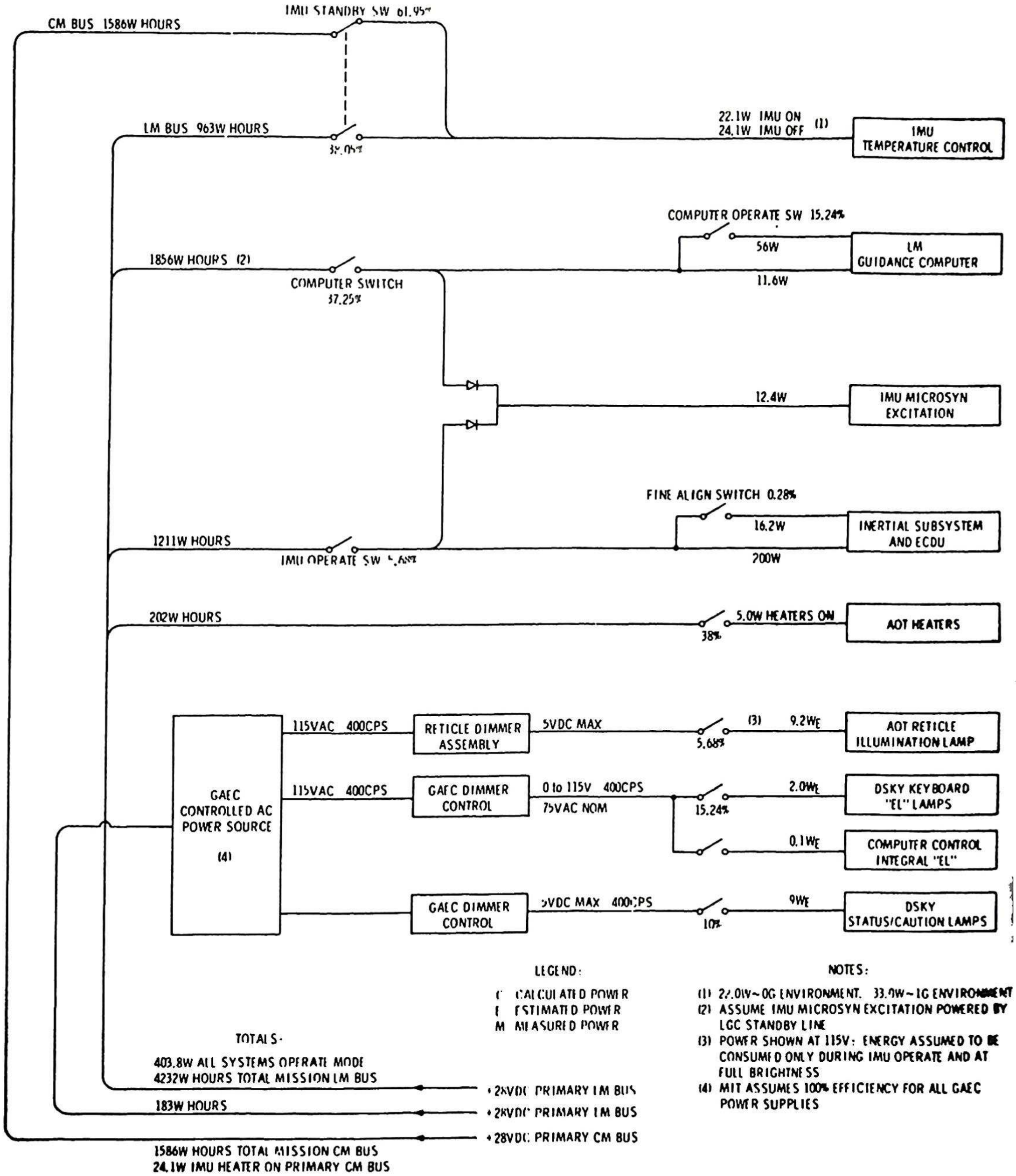
(1) 22.0W~0G ENVIRONMENT, 33.0W~1G ENVIRONMENT
(2) MIT ASSUMES 100% EFFECIENCY FOR ALL NAA POWER SUPPLIES

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 is 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-4 and subsequent LM Vehicles at GAEC.

Table 5.3 shows the configuration for major units comprising the G&N Systems assigned to CM-103 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-4	System 606	LM-5	System 609	CM-104	System 209	CM-106	System 206	CM-107	System 210	CM-101	System 204	CM-103	System 206	LM-3	System 605
INSTALLATION	X			X	X		X		X		X		X		X	
SUBSYSTEM CHECKOUT S/C	X			X	X		X				X		X		X	
INTEGRATED TEST S/C	X				X						X		X		X	
COMPLETE TESTING AT KSC											X					

DATE: 1 October 1968

CM-103, G&N System 206 completed all G&N system testing at S/C contractor and vehicle was shipped to KSC on 11 August 1968.

TABLE 5.2 LM G&N SYSTEM CONFIGURATION

S/C	LM-4		LM-5			
COMPONENT NOMENCLATURE	System 606		System 609			
	Part Number	S/N	Part Number	S/N	Part Number	S/N
LGC	2003993-031	31	2003993-031	42		
DSKY	2003994-051	65	2003994-051	54		
IMU	2018601-221	21	2018601-221	32		
ECDU	2007222-221	18	2007222-241	31		
AOT	6011000-111	16	6011000-081	15		

DATE: 1 October 1968

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

1. LM-4, G&N System 606

   A. DSKY, part number 2003994-021 S/N 65, modified to part number 2003994-051, S/N 65. Addition of protective safety glass to cover EL and IL's.

   B. AOT, part number 6011000-081 S/N 16, modified to part number 6011000-111, S/N 16. Protective cover added to CCRD harness.

2. LM-5, G&N System 609

   A. Changed IMU from part number 2018601-191, S/N 11 to 2018601-221 S/N 32. Upgrading cycle of IMU's (internal harness) per LM-3 DCR.

   B. DSKY part number 2003994-021 S/N 54 modified to part number 2003994-051 S/N 54. Addition of protective safety glass to cover EL and IL's.

TABLE 5.3 CM G&N SYSTEM CONFIGURATION AT NAR

S/C COMPONENT NOMENCLATURE	CM-104 System 209 Part Number	S/N	CM-106 System 206 Part Number	S/N	CM-107 System 210 Part Number	S/N
AGC	2003993-031	37	2003993-041	40	2003993-031	44
DSKY (Main)	2003994-051	59	2003994-051	43	2003994-021	53
DSKY (Navigation)	2003994-051	42	2003994-051	62	2003994-021	36
IMU	2018601-201	22	2018601-201	24	2018601-231	30
CDU	2007222-231	34	2007222-181	22	2007222-231	40
OPTICS	2011000-071	27	2011000-071	22	2011000-081	20

DATE: 1 October 1968

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

CM-103, G&N System 208

Vehicle shipped to KSC on 11 August 1968.

CM-104, G&N System 209

DSKY (main) and DSKY (navigation) dash numbers change from -021 to -051. Part and serial numbers remain the same. Reason for change, addition of protective safety glass to cover EL and IL's.

CM-106, G&N System 206

DSKY (main) and DSKY (navigation) dash numbers change from -021 to -051. Part and serial numbers remain the same. Reason for change, addition of protective safety glass to cover EL and IL's.

TABLE 5.4 G&N SYSTEM CONFIGURATION AT KSC

S/C	LM-3		101		103	
COMPONENT NOMENCLATURE	System 605 Part Number	S/N	System 204 Part Number	S/N	System 208 Part Number	S/N
AGC	2003993-031	32	2003993-031	27	2003993-031	33
DSKY (Main)	2003994-031	51	2003994-031	50	2003994-031	58
DSKY (Navigation)			2003994-031	64	2003994-031	48
IMU	2018601-221	19	2018601-201	8	2018601-201	23
CDU	2007222-221	27	2007222-191	15	2007222-231	35
OPTICS	6011000-074	18	2011000-071	24	2011000-071	19

DATE: 1 October 1968

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

1. LM-3, G&N System 605
   A. DSKY, part number 2003994-021, S/N 51, modified to part number 2003994-031, S/N 51. Addition of protective safety glass to cover EL and IL's.
   B. CDU, part number 2007222-221, S/N 24 removed and replaced with part number 2007222-221, S/N 27. Four volt dc voltage-level problem which upon replacement of the CDU still existed and was then charged to GSE DR (287).
   C. IMU, part number 2018601-221, S/N 15 replaced with 2018601-221, S/N 19. ADIA X term shifted 1300 meru/g.

2. CM-103, G&N System 208
   A. DSKYs part numbers 2003994-021 S/N 58 and 48 modified to part number 2003994-031. Addition of protective safety glass to cover EL and IL's.

SECTION 6

G&N SYSTEM TEST

SYSTEM TEST LABORATORY

A. G&N 5

No operating hours.

B. G&N 104

1. Hardware Tests

a. Reactivated system to conduct a series of special IRIG performance tests in conjunction with similar tests conducted on Block II IRIGs. The purpose was to measure the effect of long IRIG output-axis "soak" periods on overall normal bias performance. Results indicate that extended "soaking" does in some cases result in an exponentially varying bias term. Refer to STG Memo No. 1226 for details.

C. G&N 200

1. Program Tests

a. Continued checkout of COLOSSUS program working with Rev. 237.

b. Verified program for diagnosing gas in PIPA fluid-type problems. Full report is in process.

c. Continued checkout of Flight Simulator procedure. Verified K-START tapes for use with COLOSSUS program assembly.

d. Verified TVC/RCS DAP polarity test K-START tapes for use with COLOSSUS program assembly.

e. Verified IRIG scale-factor test K-START tapes for use with COLOSSUS program assembly.

f. Verified IMU performance test K-START tapes for use with COLOSSUS program assembly.

g. Started Level V COLOSSUS verification testing.

h. Verified IRIG scale factor test segment.

i. Completed checkout of alarm testing for Level III test.

j. Verified fix to optical verification (P03); reference Progress Report, 6 August 1968.

k. Found problem with gyro compass (P02) which prevents azimuth change if present azimuth is 180°. This will not be fixed as no launch will ever take place with this azimuth.

l. Performed special tests to check out use of CMC programs with failed IMU. This was to develop potential backup capabilities.

2. Failures

a. Replaced Y-PIPA S/N 126 with S/N 113. S/N 126 had bubble which was verified using special PIPA bubble test and unit level testing in PIPA lab.

D. G&N 600

1. Program Tests

a. Continued checkout of LUMINARY Level III STG verification tests. All tests are scheduled for completion by 10/7/68. Five anomalies were written against radar.

b. Verified DANCE 302 restart problem due to VAC area overflow. A CRS stop on the condition revealed the new job requesting a VAC area to be radar. The priority of radar is lower than P52. Further analysis is required to verify that priorities are the cause of the overflow.

2. Hardware Tests

a. Conducted system interface tests with Auxiliary Memory Unit. Verified mechanical compatibility. Determined levels of noise susceptibility. Verified test program functions. LM system program was not available for test.

b. Conducted noise susceptibility test on UPLINK interface. Evaluated noise level input required to trigger uplink through ACE input. Added diodes and a pulse height/width discriminator at the interface and measured noise effects.

c. Completed report on noise reduction tests on uplink (STG Memo No. 1232).

d. Failure of landing radar electronic assembly P-10 was confirmed by LGC program. The unit is being reshipped to contractor for repair.

FIELD OPERATIONS

A. GAEC

1. LM-4 (Mission AS 505) G&N System 606

Rework of S/C panels 1 and 2, RR and ACA has been completed. S/C returning to EM1 area for retesting.

DSKY removed for EL-IL glass (fire fix) modification repair of burned out EL has been furnished and is ready for installation.

Completed OCP-61015 PRE-FEAT test. FEAT, OCP-61018 is in progress.

2. LM-5 (Mission AS 506) G&N System 609

PRE-FEAT testing, OCP 61015, is scheduled for 22 October 1968.

3. LM-6 (Mission AS 507) G&N System 607

Replacement IMU-PTA is under test for S/C installation per LM-3 DCR.

DSKY and CCRD have not been installed in S/C.

4. LM-7 (Mission AS 508) G&N System 610

System awaiting installation in S/C.

B. KSC

1. S/C 101 (Mission AS 205) G&N System 204

Completed integrated test with L/V simulation, TCP-K-0005.

Flight Readiness Test, TCP-K-0028, is in progress.

System will be flown with potential Y PIPA bubble problem and uplink noise problems. Error analysis indicates Y PIPA problem, minor effect on mission. EM1 fix to alleviate noise to be effective with CM-104 and subsequent.

2. S/C 103 (Mission AS 503) G&N System 208

Abbreviated combined system test TCP-K-0070 is in progress.

Currently replacing fuel cells and SPS engine in service module.

3. LM-3 (Mission AS 504) G&N System 605

TCP-K-0011 combined systems test has been completed.

ECDU 4-volt measurement investigation has ended with GSE being charged with DR (287).

Altitude Chamber Test, TCP-K-0013, is in progress. Completed three manned runs, fourth manned run with J. A. McDivitt and R. L. Schweickart is in progress.

IMU to be replaced due to X gyro problem.

C. MSC

1. 2 TV-1 testing delayed due to nitrogen leak.

2. Completed verification of LM-3 K-START tapes.

3. Assisting flight support division C' and C mission.

4. Completed description of computer input/output bits for flight controllers.

D. NAR

1. CM-104 (Mission AS 504) G&N System 209

Vehicle has completed all tests at NAR and is scheduled for shipment to KSC on 3 October 1968.

2. CM-106 (Mission AS 505) G&N System 206

Individual system test, OCP 6504, has been completed.

Integrated test, OCP-131, is scheduled for 1 October 1968.

3. CM-107 (Mission AS 506) G&N System 210

Phase III installation has been completed.

4. CM-108 (Mission AS 507) G&N System 211

Phase III installation is in progress.

5. CM-109 (Mission AS 508) G&N System 212

Phase II and III installation is in progress.

SYSTEM ENGINEERING

A. Program Testing

1. DANCE Level V

The documentation of ALM 1, ALM 2, IP 2, and RP10 were completed, finishing the DANCE testing.

2. COLOSSUS Level III

The documentation for the alarms test was completed, finishing the planned COLOSSUS Level III work.

3. COLOSSUS Level V

The Level V test plan was revised and circulated (STG 1207 Rev. 1), and the schedule is available in the latest Mission Development Plan. Some runs have been made on all tests.

4. LUMINARY Level III

The following chart shows the current status of this effort:

Test	No. of Tests	No. Completed	No Documented
IOP	5	5	4
AAP	6	5	5
SEV	4	4	3
STP	5	2	2
ICP	4	2	0
ALM	1	0	0
RP	15	12	0
IP	2	2	2

The STG testing of radar programs was reviewed with MSC/Boeing representatives.

The Level III LUMINARY test plan was updated to reflect some NASA comments and other improvements.

Thetesting of LUMINARY was begun. Tests AAP1-5, IP2, IOP1-5 and SEV1-4 have been completed, and the documentation of AAP1 is ready for approval. A digital simulation control deck has been constructed for parallel digital simulation of lunar surface alignment program.

B. System Programming

1. The segments, IMUSEFUL and LUMIRIG were created for IMU performance test and IRIGSF test for LUMINARY. DSKYCHK and MARVIN, T were also assembled and are being tested.

2. The segments for the E-memory performance test, scale factor and self test were tested with the released version of COLOSSUS (237).

3. The investigation into an automatic K-START tape-generating program was continued.

4. The sum test program was modified,and STG Memo 1219 was issued describing the program.

5. An STG Memo No. 1211, "Summary, K-START Test, Digital Simulation, Problem and Solutions", was prepared.

6. The K-START tape for IRIG SF for COLOSSUS was created and verified in the STG Lab. A segment, LUMAGS, for the AGS align test with LUMINARY was created and successfully simulated digitally. STG Memo No. 1235 was issued to give the XSM for use at KSC with SUNDANCE and a changed azimuth.

7. Created K-START tape to detect PIPA bubble for use with SUNDISK ropes. Investigation of a PIPA in the STG lab detected a bubble of magnitude of +0.3 cm/sec^2 This was measured at the unit level to be of magnitude +0.4 cm/sec^2.

8. Investigated problem with IMU performance test in DANCE 292 at KSC. Determined that reason for 1600 alarm was an excessive rate of movement of the outer gimbal (4 times vertical earth rate at site). In process of trying to determine cause of restart, ran digital simulation and ran for 20 minutes after 1600 alarm, whereas the restart at KSC occurred four minutes after 1600 alarm. Continued investigation.

9. Investigated varying PIPA bias effect upon IMU performance test. Conclusion was that bias transients of the size observed with PIPAS having bubbles can cause large errors in the determination of drifts.

C. Miscellaneous

Further study was performed of the relationship between the gimbal angles, docked alignment and docking ring angle. Two AG letters, AG 373-68 and AG 412-68 with attached Memos 1209 and 1224,were prepared.

A study of the accuracy experienced in the optics positional accuracy test for S/C 103 was begun.

KSC CHECKOUT

A. STG Memo No. 1215 was written summarizing the problems detected during verification of the LM Process Spec - KSC (STP. 1) using SUNDANCE 302.

B. STG Memo No. 1219 was written to be submitted to the LM G&N checkout coordination meeting, L10N, August 21, 1968-SUNDANCE 302 K-START tape design status.

C. The following S/C 101 (SUNDISK 282) K-START tapes were sold-off and sent to KSC and MSC:

1.	F08C101-K00067-01	Launch Erasable Load
2.	F08C101-K00068-01	Mission Erasable Load
3.	F08C101-K00078-01	Simflight
4.	F08C101-K00079-03	TVC/RCS DAP Polarity Test

D. IRIG S/F and IMU Performance Test K-START tapes (SUNDANCE 302) were sent to AC Electronics, Milw.

E. The IMU Performance Test and TVC/RCS DAP Polarity Test K-START tapes for S/C 103 are being updated to COLOSSUS 237 (Level IV).

F. Reviewed S/C 101 and S/C 103 ICP's and test outlines and plans.

G. Reviewed LM-4 Test Plans and outlines.

H. K-START Tape Verification on the Digital Simulation

1. The capability to verify the DAP Polarity Tests on the Digital Simulation is being developed. The concept requires the use of the Digital Simulation in a configuration previously unavailable. This configuration subordinates the prelaunch subroutine to the flight mode of the simulation. In this way, the prelaunch subroutine is used to provide stable-member orientation and acceleration for a 1-g environment, while the flight mode simulates responses to DAP outputs. This reconfiguration is accomplished without compromising the integrity of the simulation. The result is that all simulator options (for plots, printouts, etc.) become available to provide a complete test record. At present, the reconfiguration of the simulation has been accomplished for LM tests. The SUNDANCE 292 DAP Polarity Test has been run successfully with the simulation and is now being used to develop plots and printouts to serve as a test record.

2. In parallel with the above effort, the CSM Polarity Test is being used to develop edit routines which supplement the plots and printouts referenced above. These edit routines will identify test milestones and provide additional information (eg ΔCDM values over fixed intervals, platform position at selected points) useful in evaluating the test. At present, the IMU Polarity portion of the CSM DAP Polarity Test has been successfully run with the Digital Simulation. Edited output representing test milestones, platform position, polarity and magnitude of CDU and PIPA register values over fixed intervals for each position, and tables of CDU values have been obtained.

In addition to the above simulations, the ACED operated K-START tapes for SUNDANCE 302 are now being run with the Digital Simulation. Eight of these tapes have been run to completion with no unexpected alarms. Two await successful runs. No attempt will be made to run three tapes which contain little or no erasable programming.

I. K-START Tape Delivery

1. The following tapes have been manufactured and sold off for use with COLOSSUS 237 ropes:

IRIG SCALE FACTOR	F09C103-K00083-00
IMU PERFORMANCE	F09C103-K00081-00
RCS/TVC DAP POLARITY	F09C103-K00079-00
SIMFLIGHT	F09C103-K00078-00
MISSION LOAD	F09C103-K00068-00
LAUNCH LOAD	F09C103-K00067-00

2. Development of tapes for use with LUMINARY ropes is now underway.

TEST EQUIPMENT

A. Uplink-Downlink Timer

The uplink-downlink timer is in the process of being bench tested. It is expected that the equipment will be operational in the laboratory by the middle of October.

B. Trace

Project Trace is running about three weeks behind schedule. Some costs are running over the anticipated; however,the program is not in trouble.

1. Logic Design - The self test feature has been incorporated into the design. The major problems remaining include the revision of existing drawings and the design of circuitry to interface with the tape reader. It is estimated that logic design and module location assignments will be completed this month in time for the trays to be wire wrapped in sequential fashion. The Buffer Box modifications still must be designed.

2. The major front panels should be received near the end of the month.

3. The wire wrap trays should be received from the machining operation this week.

4. Connectors for the NAFI modules present a delivery problem..

5. The wire wrap program has apparently been debugged.

6. The circuit descriptions are proceeding well. The individual test specs are still behind schedule.

7. One section of one memory was burned up during test. Parts are on order to replace same.

8. The IBM 360 edit program for the basic program has been completed and is in the process of being verified and debugged. The logic for the interpretive part of the program is nearing completion,and coding for this part of the program should commence next week.

9. Design and assembly status - The tape reader interface has been designed. The front panels have been received. The wire wrap trays have been sent out for pinning. The first NAFI connectors have been received. Repairs have been completed on the damaged memory.

10. Programming status - Only one assembly error remains in the IBM 360 edit program for the basic program traces. The basic 360 program-completion milestone is 18 October 1968.

C. PGCU

Work is continuing in an attempt to refine the PGCU circuitry and to calibrate various test parameters and accuracies.

D. Camera Eyepiece Adapter

Block I parts have been requested from NASA. We are proceeding with the design layout of the eyepiece adapter.

E. Gyro Test Circuitry

The power supply circuit has been built and is undergoing stability tests.

F. Miscellaneous Mainline Activities

Drawing review and system maintenance continue on an as required basis.

MISSION TEST PROGRAMMING

Level III, P01.2 gyro compassing rerun with large IMU errors and maximum booster sway. A digital simulator error was uncovered and fixed in completion of this task.

MISCELLANEOUS

1. Attended COLOSSUS program FACI at MSC. Review system test lab Level III test results with MSC.

2. Issued PCR to incorporate all known changes into R-577 Section 1 (COLOSSUS GSOP).

3. Prepared presentation for Quarterly Status Review meeting originally planned for 9/26/68.

SECTION 7

G&N COMPUTER STATUS

DESIGN ANALYSIS & SUPPORT

A. Analysis Facility Activities

The activity and equipment were being used to test the auxiliary memory in accordance with the requirements of T.O. 36. The activities of T.O. 36 are reported separately.

B. Field Support

1. Uplink Problem

The investigation of the uplink problem at NAR continued. The results of the investigation led to the recommendation in MIT letter AG 351-68. The change that NAR is using does not conform to the recommended change, but the NAR change should be satisfactory if the wiring to the relays that cut out the GSE lines is short.

2. GSE Loading On the Hand Controller

ACE experienced failures of the hand controller during system test. The failure was traced to the "excessive" load that the GSE places on the sign bit. A review of this circuit confirms that the GSE does load the circuit excessively. Also, it was MIT's understanding that the GSE load on that circuit was removed. However, a search of the documentation did not confirm the change. The signal was on the test connector as a possible test point to check phasing in the LM vehicle and should not be connected to a GSE load. ACE proposed making a change to the GSE, but none has been prepared.

3. Fusing of the CM Main Panel DSKY

A search was made of the documentation to determine whether a 28 V short to ground in the main panel DSKY could draw enough current to burn the SC wiring. It was determined that the computer wiring would not act as a fuse since there were at least three parallel paths of #30 wire. Inside the DSKY, most of the wiring was one wire of #30 except for a short run between the DSKY connector and the power supply which was one wire of #26; therefore, if there is a problem with the wire burning, the NAR circuit breakers would have to provide the protection, or NAR would have to fuse the DSKY 28 V-power line.

C. Miscellaneous AGC Related Activity

1. The restart monitor modules have been delivered to NASA. Three required waivers.

2. The new documentation for software release and processing was processed and was effective for the delivery of COLOSSUS ropes.

COMPONENT PROBLEMS

A. Flatpack Contamination

The contamination problem has been under continued investigation. Some special tests have been run at MIT in order to understand the effects of contamination when operating under vibration. These tests indicate that the particles are not completely free to move as was previously expected. The results of these tests will be a subject of a separate report. A brief summary of the tests and a prediction of failure rate during a mission were made in MIT letter AG 397-68.

B. Relay Vibration Life Test

A test procedure has been generated and test equipment designed to measure the degradation of a relay subjected to vibration screens. This test requires ten hours of operating vibration followed by 10^6 cycles of operation with periodic measurement of pull-in current during the tests. It is proposed that a sample of production relays be subjected to this test. The results will provide a better understanding of the relay operating failure rate during and after being subjected to the relay and IDM screens being used in production.

C. Diode Problems

1. The diode switching problem in the rope application was summarized in MIT letter AG 461-68.

2. A diode contact resistance problem is being watched closely. The new buy of diodes has had excessive V_F failure when being processed to the Flight Processing Specification.

D. Rope Cores

One rope core vendor has continued to have quality problems. As long as the other vendor continues to supply quality parts,there should be no further procurement of these cores from the vendor with problems.

SECTION 8

APOLLO GUIDANCE COMPUTER PROGRAMMING SUMMARY

SUNDISK - MANNED CSM (EARTH ORBITAL) MISSION "C"

The following activities were performed during the reporting period:

The Constants Verification in the SUNDISK Program was completed in early August.

The Flight Readiness Review (FRR) for Mission C was held on 21 August 1968.

Mission verification of the SUNDISK Program was completed by MIT/IL on 12 August 1968.

The Final Test Report for the SUNDISK Program was issued on 10 September 1968.

Planning and discussion meetings were held with NASA/MSC regarding mission support by MIT/IL. An MIT/IL Flight Support Plan was issued in early September defining the MIT/IL effort for Mission "C".

A total of 44 anomalies have been written against the SUNDISK Program to date. These anomalies have been reviewed by both MIT/IL and NASA/MSC, and none of the anomalies was found to be a cause for remanufacturing of the flight ropes.

SUNDANCE - MANNED LM (EARTH ORBITAL)

Level V testing of the SUNDANCE Program is scheduled to be completed in early October 1968.

A total of 125 anomalies has been written since the FACI.

The SUNDANCE DAP performance testing is scheduled to be completed in late November.

Mission "D"-type performance testing of the SUNDANCE Program is being conducted by MIT/IL and is scheduled for completion in early December 1968.

COLOSSUS - MANNED CSM (LUNAR CAPABILITY)

The FACI for COLOSSUS was held at MSC on 8 August 1968. Revision 237 was released to Raytheon for rope manufacturing on 23 August 1968.

Since the release of revision 237, MIT/IL has been performing performance-type testing for Mission C'. This effort is scheduled for completion in early December 1968.

Since the release of revision 237, 51 anomalies have been written. None of these anomalies to date has required the remanufacture of COLOSSUS for Mission C'.

LUMINARY - MANNED LM (LUNAR CAPABILITY)

The LUMINARY Program was in the middle stages of Level IV testing during the reporting period. The FACI for LUMINARY is presently scheduled for early November 1968.

COLOSSUS 1A - FIRST MODIFICATION PROGRAM TO COLOSSUS 1.

During the reporting period, it was decided by NASA/MSC to release a modification to the COLOSSUS program around 25 October 1968. This modification would contain the following changes from the initial release of COLOSSUS:

1. Fix anomalies from COLOSSUS 1
2. Add Star Code 00 to P23
3. Add IMU Pulse Torquing
4. Remove limitation of one-orbital-backward Integration Constraint
5. Improve navigation by rescaling mark data

MIT/IL is presently making the above changes to the COLOSSUS program and re-testing in preparation for the 25 October release.

COLOSSUS 2 - NEW CSM PROGRAM BASELINE

The development of COLOSSUS 2 program is in the preliminary stages. The major changes for COLOSSUS 2 would be the addition of CSI/CDH targeting. and an update DAP. The present planned release date for COLOSSUS 2 is scheduled for the early part of February 1969.

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	245
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	83
Delayjob	30
Restart Routine and Tables	434
Phase Table Maintenance	179
Pinball Program and Noun Tables	2926
Displays, Priolarm	700
Program Select (V37, P00, R00)	357
Self Check	314
Extended Verbs	741
RTBOP Codes	200
SXTMARK	314
IMU Mode Switching	572
IMU Compensation	250
LGC Startup	32
LGC Power Down (P06)	47
IMU Status Check	17
Systems Test (P07)	630
Interpretive Constants	35
Flagup, Flagdown	59

GENTRAN	15
DAP Data Load (R03)	50
End Bank Markers	80
TOTAL UTILITY AND SERVICE PROGRAMS	12778

II. Autopilot and Maneuver Programs

Entry DAP	812
BOOST	65
RCS	1833
TVC	1695
TWINGIMB S40.6	70
TVNG	30
KALCMANU	715
Attitude Maneuver (R60)	86
Crew Defined Maneuver (R62)	11
Vecpoint	130
Rendezvous Final Attitude (R63)	41
Middle Gimbal Display	64
CM Body Attitude	195
TOTAL AUTOPILOT AND MANEUVER PROGRAMS	5747

III. Basic Math Routines

Inflight Alignment Routines	225
Powered Flight Subroutines	187
CSM Geometry	254
Time of Free Fall	268
Conic Subroutines	1099
Orbital Integration	1509
PERIAPO	78
Lattitude, Longitude, Altitude	159
Initial Velocity	195
Lunar and Solar Ephemeris	75
Planetary Inertial Orientation	204
TOTAL BASIC MATH ROUTINES	4253

IV. Targeting Routines

Transfer Phase Initiation Search	322
Central Angles Subroutine	46
TOTAL TARGETING ROUTINES	368

V. Navigation Routines	
Measurement Incorporation	384
Preferred Tracking Attitude (R61)	280
Lunar Landmark Selection (R35)	223
Rendezvous Tracking Sighting Mark & Backup (R21, R23)	75
Rendezvous Tracking Data Processing & Backup (R22, R24)	498
Landmark Table	150
TOTAL NAVIGATION ROUTINES	1610
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)	81
Initial VG (S41.1)	20
Entry Guidance	1165
TOTAL POWERED GUIDANCE	2271
VII. Alignment Routines	
Coarse Align (R50)	80
Fine Align (R51)	116
Auto Optics (R52)	140
Sighting Mark (R53)	51
Star Data Test (R54)	43
Gyro Torquing (R55)	27
Pick-A-Pair	127
Star Catalog	223
Alternate LOS Sighting Mark (R56)	130
Optics Calibration (R57)	53
TOTAL ALIGNMENT ROUTINES	990
VIII. Miscellaneous Programs and Routines	
P27 - Update Program	306
R36 - Rendezvous Out of Plane Display	93
P30 - P31 EXT DELTA V & General Lambert Maneuver	338
R05 - S Band Antenna Display	85
R30 - Orbit Parameter Display	283
R31 - R34 Rendezvous Parameter Display Routine 1 & 2	194
R33 - CMC/LGC Clock Synchronization	26
TOTAL MISCELLANEOUS PROGRAMS AND ROUTINES	1325

IX. Mission Control Programs

P01 - Prelaunch or Service Initialization	42
P02 - Prelaunch or Service Gyrocompassing	329
P03 - Optical Verification of Gyrocompassing	189
P11 - Earth Orbit Insertion Monitor	411
P17 - TPI Search	80
P20 - Rendezvous Navigation	150
P21 - Ground Track Determination	66
P22 - Orbital Navigation	970
P23 - Cislunar Midcourse Navigation	568
P34, P74 TPI Prethrust P35, P75 TPM Prethrust	648
P37 - Return to Earth	1310
P38, P78 SOR Prethrust P39, P79 SOM Prethrust	231
P40 - SPS Thrusting P41 - RCS Thrusting	784
P47 - Thrust Monitor	58
P51, P53 IMU Orientation Determination & Backup	256
P52, P54 IMU Realign and Backup	380
P61 - Maneuver to CM/SM Sep Attitude	316
P62 - CM/SM Sep and Pre-Entry Maneuver	92
P63 - Entry Initialization	20
P64 - Post 0.05G	6
P65 - Upcontrol	27
P66 - Ballistic	4
P67 - Final Phase	36
P76 - Target Delta V	100
P77 - LM TPI Search	1
TOTAL MISSION CONTROL PROGRAMS	7074
GRAND TOTAL	36416
REMAINING FIXED MEMORY	448

TABLE 8.2

LUMINARY LGC PROGRAM

FIXED MEMORY ALLOCATION CHART (ESTIMATED)

I. Utility and Service Programs	
Interpreter, Single Precision Subroutines Fixed-Fixed Constant Pool	3211
Executive	345
Waitlist, Longcall	264
Interrupt Lead Ins	58
Interbank Communication	76
T4rupt (R10, R25)	632
Keyrupt-Uprupt	68
Downlink Program and 7 Lists	425
Fresh Start and Restart	462
Alarm and Abort	109
Delayjob	31
Restart Routine and Tables	325
Phase Table Maintenance	165
Pinball Program and Noun Tables	2965
Displays, Priolarm	702
Program Select Check (V37, P00, R00)	333
Self Check	314
Extended Verbs	720
RTB OP Codes	181
Radar Rupts	259
AOTMARK (R53)	430
Backup Marking (COAS)	20
IMU Mode Switching	572
IMU Compensation	282
LGC Startup	32
LGC Power Down (P06)	48
IMU Status Check	17
System Test (P07)	637
Interpretive Constants	35

Flagup, Flagdown	59
GENTRAN	15
DAP Data Load (R03)	150
Radar Subroutines	784
End Bank Markers	73
TOTAL UTILITY AND SERVICE PROGRAMS	13799

II. Autopilot and Maneuver Programs

Digital Autopilot	3329
KALCMANU	670
Find CDU W	441
Attitude Maneuver (R60)	99
Crew Defined Maneuver (R62)	11
Vecpoint	130
Rendezvous Final Attitude (R63)	67
Ball Angle Display	50
Middle Gimbal Display	64
TOTAL AUTOPILOT AND MANEUVER PROGRAMS	4861

III. Basic Math Routines

Inflight Alignment Routines	227
Powered Flight Subroutines	187
LM Geometry	99
Time of Free Fall	268
Conic Subroutines	1099
Orbital Integration	1510
PERIAPO	78
Latitude, Longitude, Altitude	159
Initial Velocity	195
Lunar and Solar Ephemeris	126
Planetary Inertial Orientation	206
TOTAL BASIC MATH ROUTINES	4154

IV. Targeting Routines

Coelliptic Sequence Initiation Constant Delta Altitude	649
TOTAL TARGETING ROUTINES	649

V. Navigation Routines	
Measurement Incorporation	384
Preferred Tracking Attitude (R61)	122
Rendezvous Navigation (LSR22.3, RADARANG)	535
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	1691
VI. Powered Guidance Routines	
Servicer (R12)	1156
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)	731
Throttle Logic	129
Ascent Guidance	558
TRIMGIMB (S41.1, S40.6)	44
TOTAL POWERED GUIDANCE ROUTINES	3027
VII. Alignment Routines	
Coarse Align (R50)	61
Fine Align (R51)	135
Auto Optics (R52)	65
Star Data Test (R54)	41
Gyro Torquing (R55)	27
Pick-A-Pair (R56)	132
Lunar Surface Sighting Routine	225
Star Catalog	223
TOTAL ALIGNMENT ROUTINES	909
VIII. Miscellaneous Programs and Routines	
R47 - AGS Initialization	138
R36 - Rendezvous Out of Plane Display	93
P27 - Update Program	306
P30 - External Delta V Prethrust	80
P31 - General Lambert Maneuver	75
R04 - RR/LR Self Test R77 - LR Spurious Return Test	157
R05 - S Band Antenna Display	132

R29 - Rendezvous Radar Flight Designate	332
R30 - Orbit Parameter Display	278
R31 - Rendezvous Parameter Display	177
R33 - CMC/LGC Clock Synchronization	27
R10 - Landing Analog Display Monitor	454
R11 - Abort Discretes Monitor	56
R13 - Auto Modes Monitor	41
TOTAL MISCELLANEOUS PROGRAMS AND ROUTINES	2346

IX. Mission Control Programs

P12 - Ascent Guidance	178
P20 - Rendezvous Navigation	360
P21 - Ground Track Determination	66
P22 - Lunar Surface Navigation	20
P25 - Preferred Tracking Attitude	54
P32-P72 CSI Prethrust	93
P33-P73 CDH Prethrust	140
P34-P74 TPI Prethrust	642
P38-P78 SOR Prethrust P39-P79 SOM Prethrust	230
P40 - DPS Thrust	872
P41 - RCS Thrust	78
P42 - APS Thrust	20
P47 - Thrust Monitor	63
P51 - IMU Orientation Determination	263
P52 - IMU Realign	207
P57 - Lunar Surface Align	600
P63 - Landing Braking P64 - Landing Approach	177
P65 - Landing (AUTO) P66 - Landing (ROD) P67 - Landing (Manual)	45
P68 - Landing Conformation	--
P70 - DPS Abort	317
P71 - APS Abort	35
P76 - Target Delta V	100
TOTAL MISSION CONTROL PROGRAMS	4560
GRAND TOTAL	35996
REMAINING FIXED MEMORY	868

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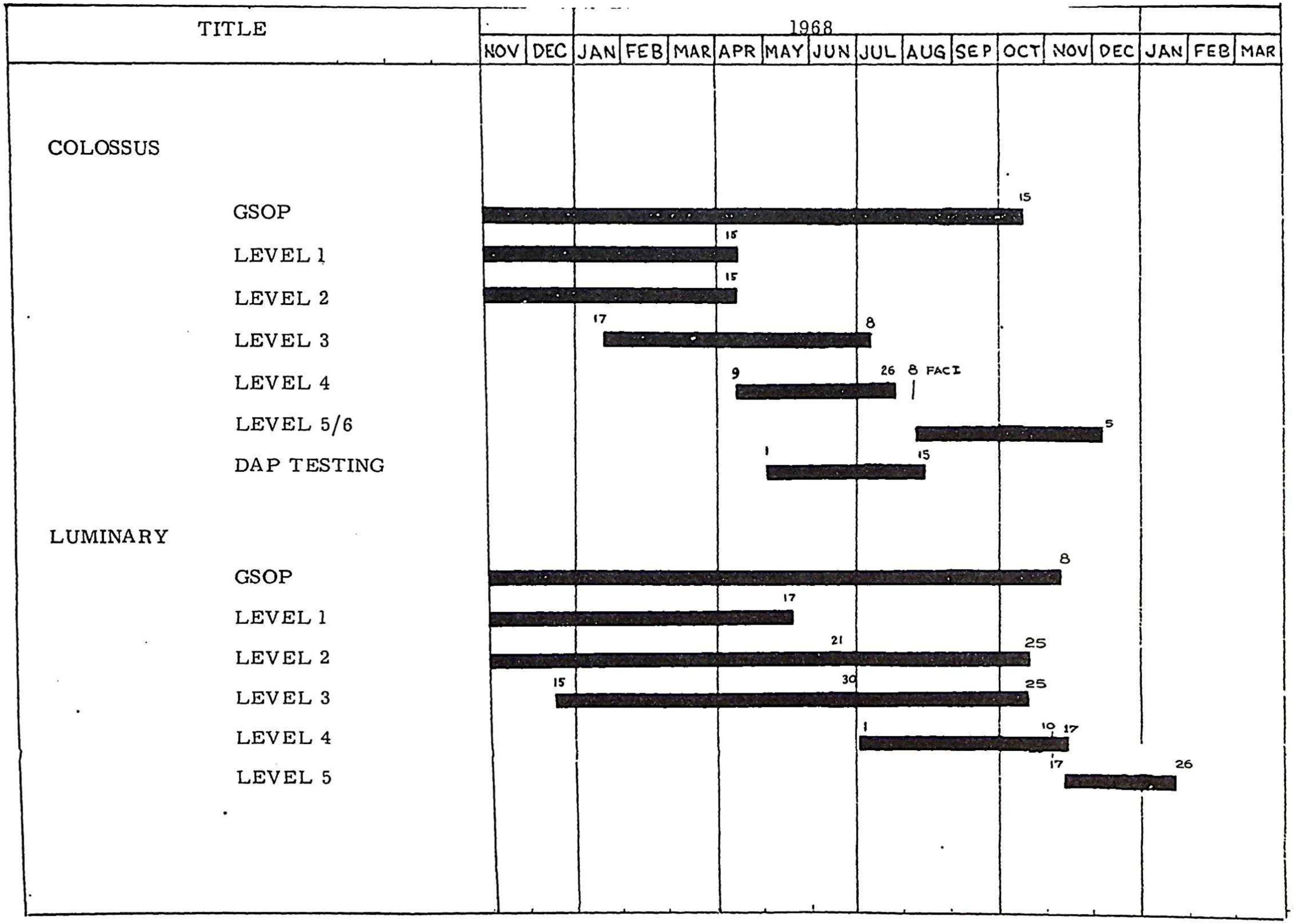

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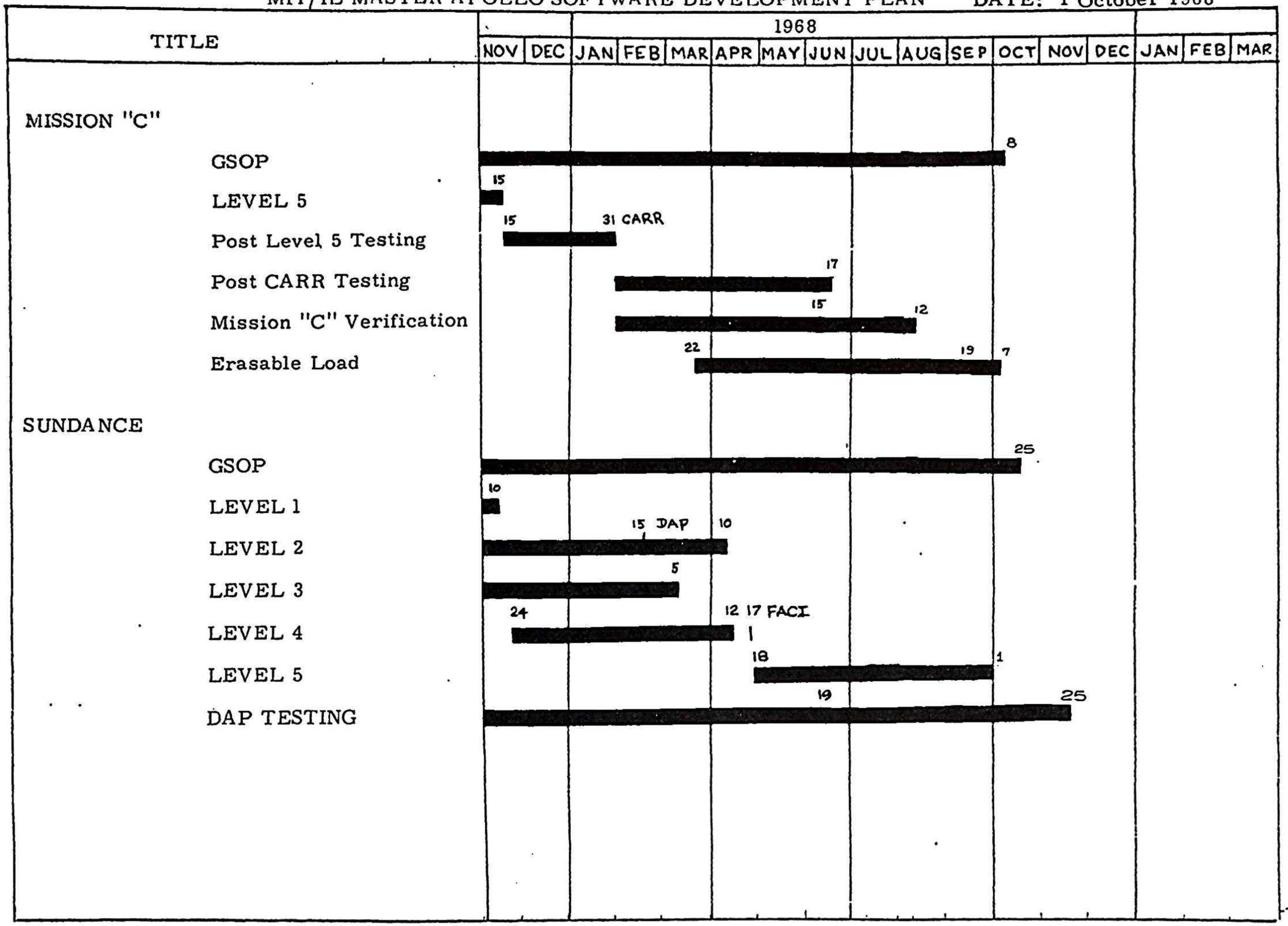

SECTION 9

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

E-1142 System Status Report, Rev. 58, August 1968 (U)

E-2262 Studies of On-Board Lunar Orbital Navigation with Unknown and Known Landmarks and Some Observations on Non-Linear Effect, August 1968 (U)

E-2280 Solid State DSKY Study, August 1968 (U)

E-2303 Final Report - Inertial Reference System Study for the Boeing Company, October 1968 (U)

E-2334 The PIPA (Pulsed Integrating Pendulous Accelerometer), September 1968 (U)

R-547 GSOP for Manned CM Earth Orbital Mission Using Program SUNDISK, Section 2 Data Links (Rev. 2), October 1968 (U)

R-557 GSOP for Manned LM Earth Orbital Missions Using Program SUNDANCE, Section 2 Data Links (Rev. 2), September 1968 (U)

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