APOLLO

GUIDANCE, NAVIGATION AND CONTROL

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APOLLO GUIDANCE AND NAVIGATION PROGRAM

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E-1142
(Rev. 60)

SYSTEM STATUS REPORT

JANUARY 1969

MIT INSTRUMENTATION LABORATORY
CAMBRIDGE 39, MASSACHUSETTS

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E-1142

(Rev. 60)

SYSTEM STATUS REPORT

ABSTRACT

The System Status Report is now distributed quarterly. The areas of activity reported on in this revision include, but are not limited to, the following for the Block II Command Modules and Lunar Excusion Module equipment: reliability failure rates, 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:

Section 1	Reliability - Failure Rates
Section 2	Guidance and Navigation Systems Status
Section 3	G&N System Test
Section 4	G&N Computer Status
Section 5	Guidance Computer Programming
Section 6	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.

NOTE

In this and following issues the section entitled Glossary and System Definition have been deleted. If there are any significant changes, the section will be reinstated.

SECTION 1

RELIABILITY - FAILURE RATES

The current status of reliability analysis is reported in summary form in Table 1.1. 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 1.1 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 2

GUIDANCE AND NAVIGATION SYSTEMS STATUS

The status of delivered G&N Systems is shown in tabular form. Table 2.1 shows the status of G&N Systems progressing from installation to final test at KSC.

Table 2.2 shows the configuration for major units comprising the G&N Systems assigned to LM-4 and subsequent LM Vehicles at GAEC.

Table 2.3 shows the configuration for major units comprising the G&N Systems assigned to CM-103 and subsequent Command Modules at NAR.

Table 2.4 shows the configuration for major units comprising the G&N Systems at KSC.

TABLE 2.1 DELIVERED G&N SYSTEM STATUS

OPERATION	LOCATION											
	GAEC						NAR					
	LM-5	System 609	LM-6	System 607	LM-7	System 610	CM-107	System 210	CM-108	System 211	CM-109	System 212
INSTALLATION	X		X		X		X		X		X	
SUBSYSTEM CHECKOUT S/C	X		X				X		X			
INTEGRATED TEST S/C	X						X					
COMPLETE TESTING AT KSC												

OPERATION	LOCATION							
	KSC							
	CM-104	System 209	CM-106	System 206	LM-3	System 605	LM-4	System 606
INSTALLATION	X		X		X		X	
SUBSYSTEM CHECKOUT S/C	X		X		X		X	
INTEGRATED TEST S/C	X		X		X		X	
COMPLETE TESTING AT KSC								

DATE: 1 January 1969

1. CM-101, G&N System 204, successfully completed mission AS-205 in October 1968.
2. CM-104, G&N System 209, completed all G&N Systems testing at S/C contractors and vehicle was shipped to KSC on 3 October 1968.
3. LM-4, G&N System 606, completed all G&N Systems testing at S/C contractors and vehicle was shipped to KSC on 15 October 1968.
4. CM-106, G&N System 206, completed all G&N Systems testing at S/C contractors and vehicle was shipped to KSC, 24 November 1968.
5. CM-103, G&N System 208, successfully completed mission AS-503 in December 1968.

TABLE 2.2 LM G&N SYSTEM CONFIGURATION

S/C	LM-5		LM-6		LM-7	
COMPONENT NOMENCLATURE	System 609 Part Number	S/N	System 607 Part Number	S/N	System 610 Part Number	S/N
LGC	2003993-031	42	2003993-031	45	2003993-031	46
DSKY	2003994-051	54	2003994-051	56	2003994-051	61
IMU	2018601-221	32	2018601-221	33	2018601-221	37
ECDU	2007222-241	31	2007222-241	32	2007222-241	37
AOT	6011000-111	15	6011000-081	19	6011000-111	20

DATE: 1 January 1969

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

1. LM-4, G&N System 606

   Vehicle shipped to KSC on 15 October 1968.

2. LM-5, G&N System 609

   AOT Dash Number changed from -081 to -111. Reason for change, flammability fix to heater wires.

TABLE 2.3 CM G&N SYSTEM CONFIGURATION AT NAR

S/C	CM-107		CM-108		CM-109	
COMPONENT NOMENCLATURE	System 210 Part Number	S/N	System 211 Part Number	S/N	System 212 Part Number	S/N
AGC	2003993-031	44	2003993-031	34	2003993-031	50
DSKY (Main)	2003994-051	53	2003994-051	67	2003994-051	72
DSKY (Navigation)	2003994-051	66	2003994-051	74	2003994-051	73
IMU	2018601-231	30	2018601-231	20	2018601-231	29
CDU	2007222-231	40	2007222-231	41	2007222-231	42
OPTICS	2011000-081	20	2011000-081	26	2011000-081	18

DATE: 1 January 1969

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

CM-104, G&N System 209
Vehicle shipped to KSC on 3 October 1968.

CM-106, G&N System 206
Vehicle shipped to KSC on 24 November 1968.

CM-107, G&N System 210
DSKY (Main) and DSKY (Navigation) Dash numbers change from -021 to -051. Reason for change, addition of protective safety glass to cover EL and ILs. Navigation DSKY changed S/N 36 to 66. Due to malfunctioning numeral 8 push button.

CM-108, G&N System 211
CDU, Part Number 2007222-181, S/N 16, removed and replaced with part number 2007222-231, S/N 41. Exchanged Block I flat packs with Block II.

TABLE 2.4 G&N SYSTEM CONFIGURATION AT KSC

S/C	LM-3		LM-4		CM-104		CM-106	
COMPONENT NOMENCLATURE	System 605 Part Number	S/N	System 606 Part Number	S/N	System 209 Part Number	S/N	System 206 Part Number	S/N
AGC	2003993-031	32	2003993-031	31	2003993-031	37	2003993-041	40
DSKY (Main)	2003994-031	51	2003994-051	65	2003994-051	59	2003994-051	43
DSKY (Navigation)					2003994-051	42	2003994-051	62
IMU	2018601-221	19	2018601-221	27	2018601-201	22	2018601-201	24
CDU	2007222-221	11	2007222-241	38	2007222-231	34	2007222-181	22
OPTICS	6011000-074	18	6011000-111	16	2011000-071	27	2011000-071	22

DATE: 1 January 1969

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. CDU, Part number 2007222-221, S/N 27, removed and replaced with part number 2007222-221, S/N 11. CDU was subjected to reverse voltage.

2. LM-4, G&N System 605
   A. CDU, part number 2007222-221, S/N 18, removed and replaced with part number 2007222-241, S/N 38. CDU was subjected to reverse voltage.

   B. IMU, part number 2018601-221, S/N 21, removed and replaced with part number 2018601-221, S/N 27. X gyro parameters out of specification.

3. CM-101, G&N System 204
   Successfully completed mission AS-205, in October 1968.

4. CM-103, G&N System 208
   Successfully completed mission AS-503 in December 1968.

SECTION 3

G&N SYSTEM TEST

SYSTEM TEST LABORATORY

A. G&N 5

No operating hours.

B. G&N 104

No operating hours.

C. G&N 200

1. Program Tests

a. Level 5 testing on COLOSSUS Rev. 237 was completed.

b. Supported checkout of P37 in COLOSSUS 237 for S/C 103 mission.

c. Verified special erasable downlink program requested by AC Electronics for use during IMU Performance Test on COLOSSUS 237.

d. Verified special erasable program to hold gimbal orientation between steps of IMU Performance Test on COLOSSUS 237.

e. Verified program P01, P02 and P03 as part of COLOSSUS 249 verification - Level V test.

f. Continued checkout of Simflight test for S/C 103 and S/C 104.

g. Checked out erasable program to be used with VHF checkout at KSC.

h. Supported work associated with Coroner Program.

i. Supported Apollo 8 flight.

j. PIPA bubble test report has been written and distributed (STG Memo No. 1277).

k. Verified Erasable Launch Load, Erasable Mission Load, and a special PIPA bubble test K-START tapes for use with SUNDISK program assembly.

l. Verified Erasable Launch Load, Erasable Mission Load, Simflight, IMU Performance test, and IRIG Scale Factor test K-START tapes for use with COLOSSUS program assembly.

2. Hardware Test

a. Performed special testing on Z PIPA to determine whether PIPA or PIPA electronics were bad. Determined that problem was in electronics.

b. Checked out VHF generator used for radar ranging in P20.

c. Attempting to duplicate CDU Trunnion problem as it appeared on Apollo 8 flight.

3. Failures

a. Failure analysis of the Z PIPA electronics modules is continuing on a low priority basis. The failure was isolated to erratic behavior of the A.C. Diff. Amp. and Interr., S/N HUG 256 but has not been isolated to a particular component in the module.

D. G&N 600

1. Program Tests

a. Continued checkout of LUMINARY revision 51 through 64 in preparation for LUMINARY Level V tests. Level III STG verification tests were completed. Development of P57 tests and LR Servicer routines were accomplished.

b. Performed checkout of DANCE 306 changes and K-START tapes (STG Memo No. 1246).

c. Verified Simflight procedures with DANCE 302 and DANCE 306. Continued LUMINARY Simflight development.

d. Zeros with even parity are now hand loaded into all unused locations in the CRS. This is done to simulate the actual ropes.

e. The preliminary IMU Performance K-START tapes for LUMINARY Revision 60 through 64 were verified.

f. Verified IMU Performance test and AGS Align Test K-START tapes for use with SUNDANCE program assembly.

g. Performed LUMINARY Level V tests on Rev. 69. Testing is expected to be completed 24 January 1969.

h. Continued development of LUMINARY Simflight K-START tape.

i. Verified IMU Performance test, IRIG Scale Factor test and IMU-ASA Mechanical Alignment test K-START tapes for use with LUMINARY program assembly.

j. Performed a simulated hand controller test to verify RCS jet firings at KSC.

k. Ran landing radar simulation tapes using Aurora 88. The radar was a flight hardware configuration.

l. Developed erasable program to test RCS and GTS autopilot.

2. Hardware Tests

a. Conducted reverse voltage measurements on G&N system in support of LM-3 and LM-4 problems (AG #537-68).

b. Tests were conducted to measure the peak current drawn by the DSKY lamps during DSKY Lamp test (V35).

c. The auxiliary memory unit was tested in the Lab. These appears to be a problem with the Erasable Program used to exercise the interface between the auxiliary memory and the computer normal memory. Tests will be completed when the erasable program is debugged.

d. Performance data on the Nortronics gyro (S/N PPD1) installed in the STG Lab SYS 600-Z-axis was plotted. (STG Memo No. 1286).

3. Hardware Modifications

a. A modification was made to the jet monitor panel. The jet lights are now mounted on outriggers of a black box LM mounted on the ROTAB. Jet firing can now be correlated with motion on a visual basis.

b. Removed the X, Y, and Z-gyros from the system for component level tests. The component level tests indicated that both the Y and Z-gyros were bad. The Z-gyro had an ADIA instability problem. The Y-gyro had developed a problem with the gyro wheel bearing. The run-down time had changed from approximately 85 seconds to 25 seconds.

c. The Z-gyro was replaced with the Nortronics PD-1 in order to evaluate the gyro wheel performance.

d. Two gyros were removed from the 600 system. Component level tests were performed on the above gyros. Test results indicated that S/N 92 was the best gyro available. S/N 92 was installed in the Y slot on the system.

e. The CDU, LGC and PSA cold plates were replaced due to leaks and an open in the temperature indicating circuit.

f. Removed PSA, CDU, LGC cold plates, and installed new sensors.

g. Removed DSKY S/N P001 and replaced it with DSKY S/N RAY 17 due to bad relay.

FIELD OPERATIONS

A. GAEC

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

Complete PRE-FEAT testing OCP 61015, Phase III CARR, FEAT and plugs out OCP 61018, and vehicle is awaiting shipment.

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

PRE-FEAT testing, OCP 61015 has been completed.

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

Equipment has been installed in vehicle. Individual Systems Test, OCP 62000, is in progress. A new IMU and PTA have been installed in the vehicle due to apparent failure in heater circuitry.

B. KSC

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

Complete Integrated Test with L/V simulation TCP-K-0005. ADSRA Z failed D criteria but retest is okay. During SCS aborts, the CDU evidently received an external CDU zero signal. +28 V bus transient was the probable cause. Completed Flight Readiness test TCP-K-0028.

2. S/C 104 (Mission AS-504) G&N System 209

Vehicle located in Altitude Chamber. Abbreviated Combined System Test, OCP-K-0070 completed 31 October 1968. Vehicle awaiting move to VAB.

3. S/C 106 (Mission 505) G&N System 206

Vehicle located in MSOB. Completed abbreviated combined systems test, TCP-K-0070.

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

CDU problem not yet resolved, CDU and PSA have been replaced. Rendezvous radar is presently working. Vehicle awaiting move to LC - 39B.

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

Altitude testing, TCP-KL-0013 completed. Spacecraft awaiting transport MSOB to VAB.

C. MSC

1. Completed first altitude run on LTA-8 with no problems.

2. Supported C' Simflight.

3. Coordinated MIT effort on C' Mission.

4. Supported C' Mission.

5. Analyzed and transmitted data on 205 Mission to MIT/IL.

D. NAR

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

Completed Integrated Test, OCP 131. Vehicle shipped to KSC.

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

Vehicle has completed all tests at NAR and is awaiting shipment to KSC.

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

Completed installation of G&N equipment. Individual System Test, OCP 6504 and combined system test, OCP 126 have been completed.

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

Phase III installation has been completed. Awaiting start of individual system test, OCP 6504.

5. CM-110 (Mission AS-509) G&N System 214

Phase II and III installation is in progress.

SYSTEM ENGINEERING

A. Program Testing

1. SUNDANCE

A special series of tests were run on Rev. 306 of SUNDANCE and a report (STG No. 1246) was issued.

2. COLOSSUS Level V

a. The COLOSSUS I (Rev. 237) testing was completed and a report (STG Memo 1253) was distributed.

b. A COLOSSUS IA (Rev. 249) test plan was prepared (STG Memo 1247). All testing was completed and a report (STG Memo 1283) was distributed. The calculation of more accurate values for the optics pointing angles in P03 with the IMU out of the fixture was continued.

c. A plan for testing of COLOSSUS II (STG Memo 1268) was prepared and distributed. A schedule of tests starting in January 1969 was also distributed. (STG Memo 1273).

3. LUMINARY Level III

The LUMINARY Level III testing has been completed. Documentation was distributed (STG Memo 1225 series) and the Pre-FACI meeting was supported.

4. LUMINARY Level V

a. A LUMINARY Level V test plan was prepared. A special test of R12, LR read and measurement program, was run. A study of transformations to be used in this testing was completed (STG Memo 1257) and a special test of P57 was run testing these transformations.

b. The status of LUMINARY Level V tests is as follows:

1) IOP's-IMU Operational Programs - all tests performed and documentation awaiting approval.

2) AAP's - AOT Alignment Programs - No tests performed.

3) SEV's - System Extended Verbs - 2 of 4 tests performed and documented.

4) ICP's - IMU Compensation Program - All tests performed and documented.

5) ALM - Alarms - Performed and documented.

6) RP's - Radar Programs - 8 of 15 tests performed.

7) STP - System Test Programs - 2 of 4 formally tested and 1 documented.

B. System Programming

1. The performance test for DANCE 306 was updated to include program which terminates test when overflow (1600 alarm) occurs. The IRIG SF test was also updated. Both programs were digitally simulated and the K-START tapes lab verified.

2. The COLOSSUS IA K-START tapes were changed to add a program to correct errors in reading and zeroing PIPA's.

3. The program PIPABUBL to detect PIPA bubbles has been simulated for DANCE. This will also be prepared for COLOSSUS and LUMINARY and tapes will be made.

4. A PIPA orthogonality test, PIPORTHO, is being assembled for use with COLOSSUS, DANCE, and LUMINARY.

5. Erasable downlink program segments LUMYDOWN, COLTDOWN and DANCEDWN, were created.

6. The K-START tapes for the performance test with COLOSSUS 237 and 249 were generated. This program includes the special erasable downlink program. The K-START tapes for SUNDANCE performance tests are being updated to include the downlink program.

7. Digital simulations of the IMU performance test and IRIG SF test were run on LUM 69 and K-START tapes were generated.

8. The AGS align test K-START tape for DANCE 302 was checked out for DANCE 306. A memo (STG 1251) was issued giving the information required for use of this tape in the MSOB rather than at LC-39.

C. Flight Support

The Apollo 8 mission was supported by personnel in the SCAMA room. Considerable planning for this support was also performed.

D. M-439 Experiment

Met with MSC on 7 October 1968 and concluded:

1. No further testing would be conducted until after 1 December 1968.

2. Program "COLOM 439" would be tailored to MSC requirements for a ground test using a horizon simulator and real stars. More detailed requirements will be forthcoming from MSC after 1 December 1968 as they become known.

3. "COLOM 439" testing would make use of Simflight testing techniques wherever possible and

4. Field support at MSC would be supplied by MIT by beginning of the testing.

E. Auxiliary Memory Project

The ACM/ATM Hardware was rechecked and brought to the STG lab on 24 and 25 October 1968. Interface problems, software bugs and CRS memory problems were encountered.

Segment AMDANCE was modified and reassembled to allow proper bank switching between AMDANCE and SUNDANCE 306. STG lab testing was not successful in operation with the ACM and AMDANCE Rev. 8. Patches to Rev. 8, plus changes to the AGC simulator to expand memory allocations and allow an "ADS BBANK" operation, permitted a simulation run which cycles the segment and operated the system such as to allow platform (S.M.) leveling to be maintained for one hour of AGC time. A bug remains in the gyrocompassing loop, but the program in its present state should allow further testing of AMDANCE and the auxiliary memory in the STG lab. This problem turned over to the Digital Development Group for further action.

F. Star Tracker Study

Began investigation on the requirements for adding a search routine to P23 to be used by a star tracker in the event an acquire signal is not obtained after driving the sextant LOS to the calculated position. This study is in conjunction with an automatic realignment capability addition to P23.

G. Miscellaneous

The study of the accuracy that can be achieved with S/C 103 optics, was completed.

A program to analyze Gyro and Accelerometer Test Data was prepared. This is documented in STG Memo No. 1263.

KSC CHECKOUT

A. K-START Tape Verification on the Digital Simulation

1. SUNDANCE 302 K-START tapes provided by AC Electronics were run on the MIT/IL Digital Simulation. The final report, STG Memo No. 1245, was provided to NASA/MSC (AG #520-68).

2. COLOSSUS IA and LUMINARY segments for DSKYCHK and MARVIN, T are being assembled and verified with the MIT/IL Digital Simulation.

3. The verification of the LM RCS/TVC DAP Polarity Test on the MIT/IL Digital Simulation using SUNDANCE 292, 302, and 306 program assemblies was completed. Final plots, edited output and computer listings were presented to the LM G&N Checkout Coordination Meeting at MSC, and the SUNDANCE 302 data was sent to KSC to be reconciled with actual spacecraft test results.

4. At the request of the LM G&N Checkout Coordination Meeting the LM RCS/TVC DAP Polarity Test was simulated for SUNDANCE 306 at a KSC azimuth of 166°. The simulation results were provided to KSC to support the development of LM-4 OCP's.

5. A number of special simulations were performed to support the analysis of KSC IDR #7 TPS 255. None of these simulations duplicated the problems encountered at KSC. All results were nominal. The problem being investigated involved erroneous jet firing profiles which developed with AC K-START tape F07L003-K10525-00. R04 (Radar Self Test) was running in the background.

6. The simulation of COLOSSUS 237 K-START Tapes provided by AC Electronics was completed. Many problems were encountered in trying to simulate the GN&C Interface Tape. These were simulation problems rather than problems with the test itself.

7. SUNDANCE 306 and COLOSSUS 249 K-START Tapes provided by AC Electronics are currently being simulated.

8. The verification of the CM RCS/TVC DAP Polarity Test for COLOSSUS 237 continues. The availability for CM Simulations of the same simulation configuration used to simulate the LM RCS/TVC DAP Polarity Test is expected by mid-January.

The simulation of the test itself is proceeding and is 70% complete. A number of problems are being encountered handling the large volume of astronaut cards required. The present objective is to complete the simulation of both COLOSSUS 237 and COLOSSUS IA tests by 23 January 1969. Though optimistic, this data has been established to support the CM-104 test schedule.

B. K-START Tape Delivery

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

SUNDISK 282

F08C101-K00067-04 to 10	Erasable Launch Load for S/C-101
F08C101-K00068-03	Erasable Mission Load for S/C-101
F08C101-K00087-00	IMUPERFHELP for S/C-101
F09C101-K00089-00	PIPA Bubble Test

SUNDANCE 292

F07L003-K00081-06	IMU Performance Test

SUNDANCE 302

F07L003-K00067-04	Erasable Launch Load for LM-3 (VAB)
F07L003-K00068-04	Erasable Mission Load for LM-3 (VAB)
F07L003-K00078-04	Simflight for LM-3 (VAB)
F07L003-K00081-05	IMU Performance Test

SUNDANCE 306

F07L003-K00078-05	Simflight for LM-3 (PAD)
F07L003-K00067-05	Launch Load for LM-3 (PAD)
F07L003-K00068-05	Mission Load for LM-3 (PAD)
F07L003-K00081-04	IMU Performance Test
F07L003-K00083-03	IRIG Scale Factor Test

COLOSSUS 237

F09C103-K00081-01	IMU Performance Test
F09C103-K00079-01	RCS/TVC DAP Polarity Test
F09C103-K00078-01	Simflight for LM-3 (PAD)
F09C103-K00068-01 to 04	Erasable Mission Loads for CM-103
F09C103-K00067-01 to 10	Erasable Launch Loads for CM-103
F09C104-K00079-00	RCS/TVC DAP Polarity Test for CM-104

F09C104-K00067-00	Erasable Launch Load for CM-104
F09C104-K00068-00	Erasable Mission Load for CM-104
F09C104-K00078-00	Simflight for CM-104

COLOSSUS IA 249

F09C104-K00079-01	CM RCS/TVC DAP Polarity Test for CM-104 (PAD)
F09C104-K00078-00	Simflight for CM-104 (PAD)
F09C104-K00081-00	IMU Performance Test
F09C104-K00083-00	IRIG Scale Factor Test

C. Development of a capability to manufacture K-START tapes directly from segments assembled in the IBM-360 computer has been developed. This change simplifies the manufacture cycle by eliminating the need for maintaining K-START card decks. The following tapes are now being converted to this manufacturing process:

IMU Performance Test
IMU ASA Mechanical Alignment Test

D. The segment CINDYSUE (DSKYCHK and MARVIN, T) was assembled for SUNDANCE 306 and provided to AC Electronics for K-START tape manufacture (AG #523-68).

E. K-START tapes for use with SUNDANCE 306, COLOSSUS IA, and LUMINARY ropes at KSC are currently being developed. IMU Performance Tests for previous assemblies are being updated.

F. A program is being developed to perform angle computations for the AOT Functional Accuracy Test. This program has been assembled as a segment for SUNDANCE 302 and 306. The program is not completely debugged. Simulations and STG Lab runs are being used to complete this effort.

G. The development of COLOSSUS IA and LUMINARY 69 K-START tapes continues. The gyro torquing function in the LM RCS/TVC DAP Polarity Test is being replaced by an erasable program similar to that program used with the CM RCS/DAP Polarity Test.

TEST EQUIPMENT

A. Uplink - Downlink Timer

The timer is operational in the system test lab except for connection with the uplink transmitter. In order to avoid any possible system downtime it has been

decided to delay this hookup until the second uplink transmitter (with uplink - downlink interface) becomes available. The first uplink transmitter will then be modified and used with the LM station.

B. Trace

1. Logic Design - the project completion date now appears to be 30 July 1969, with documentation scheduled for completion by 30 August 1969. The major problems are the wire listing and wire wrapping programs. The initial attempt to obtain a satisfactory logic module location assignment resulted in a one-month slip; however, assignments have now been completed.

The buffer box interface circuits still need to be breadboarded. Although no significant design effort has been made in this area, voltage measurements of the existing facilities around the laboratory have been made to determine the necessary threshold levels. There appears to be an adequate region between the "O" and "I" voltages for all equipments and no adjustments would appear necessary for a particular installation.

2. The Coroner front panels are in assembly. The only drawbacks in this area are in the fabrication of the PC boards for the lamp drivers and the lack of wiring information. Some effort has been made to generate front panel wiring information; however, this effort has been hampered by the lack of the computer wire listing.

3. The wire wrap trays were expected to have been completed by this time. A problem developed in that the vendor could not pin the trays satisfactorily for various reasons ranging from pull out values, pin alignment and crumbling of the insulators. In addition, the vendor would have to pin the trays manually rather than automatically. These trays were drilled, deburred and countersunk in conformance with the practice and standards used on the Poseidon contract. We are now going to use Poseidon vendors (although more expensive for the same result) to get the job done. This has caused a two month slip and has caused it to become the critical path.

The wire wrap trays are expected to be returned from Masterite in early January. The grounding pins should arrive from Malco at approximately the same time. The grounding pins will then have to be installed and the trays sent out for wiring wrap when the program is completed.

4. Connector for the NAFI modules are in house and no longer a problem.

5. The NAFI modules continue to remain a problem although at this date the problem has shifted from the NAFI connectors to the PC boards themselves. The initial vendor has failed to produce a satisfactory product. A new vendor has been located. One of the problems which the vendors have apparently been having with the PC boards is the front-to-back registration which reduces the pad around the plated-

through holes to marginal levels. A review of the manufacturing and usage processes indicates that a small amount of redesign will easily correct the problem and provide satisfactory boards. It is expected that the boards will be in house by mid January.

6. Description of the logic schematics are nearing completion. They should be completed this month.

7. 360 Edit Program

The interpretive section of the 360 Edit program has been coded and is awaiting assembly into the main program. A tape is being generated to simulate the Coroner output so that both halves of the Edit program can be functionally verified. It is estimated that the work will be completed in late January.

C. Camera Eyepiece Adapter

Preliminary sketches have been completed with the exception of some details in the area of camera mounting. Details of the camera mounting interface requirements have been obtained.

Work has ceased at this juncture pending availability of personnel and funds. The relay lens assemblies which we had planned to use inthese assemblies were delivered to NASA/MSC at their request to satisfy other program requirements.

D. Miscellaneous Mainline Activities

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

MISCELLANEOUS

1. Summarized and documented the test results and analysis in support of solution of the reverse voltage problem in LM (STG Memo No. 1238).

2. Supported NASA meeting for resolution of LM Abort Electronics Assembly restart problem.

3. Supported the launch, post-launch and astronaut debriefing of the Apollo 7 mission.

4. The 360 manufacturing program has been modified so that CRS Digitstore tapes now have a zero with even parity in all unused locations to make the testing programs identical to the flight rope programs.

5. Participated in FACI review of LUMINARY Level III test results. All System Test Laboratory tests results were satisfactory.

6. Participated in Hardware Committee review and report for Apollo 7 (STG Memo No. 1262).

7. Participated in the COLOSSUS CARR/FSRR meeting with a presentation on System Test Laboratory test results.

8. Reviewed flight plans for Apollo 8 and established "red lines" for G&N parameters.

9. Participated in simulations in support of Apollo 8.

10. Supported Apollo 8 at KSC and at MIT during mission.

11. Reviewed ACED-submitted TDRRs.

SECTION 4

G&N COMPUTER STATUS

DESIGN ANALYSIS & SUPPORT

A. Analysis Facility Activities

The equipment continued to be used in support of the auxiliary memory tests in pursuant of the requirements of T.O. 36. The only exception was a simulation of the rope failure that occurred in LM 4 during vacuum tests. The symptoms of the failure were simulated.

B. Field Support

1. The two major field problems that developed during testing at KSC, mainly the rope failure during vacuum testing of LM 4 and the EL light failure during vacuum testing of CM 104, have been analyzed.

The rope problem was determined to be a workmanship type of defect that was not detected during sale of the rope modules. The failure was intermittant in nature and was detectable by continuously monitoring the rope operation while subjecting the rope to either vacuum or temperature cycling. The tests used during sale monitors at the end points only and thus did not detect the fault. Continuous monitoring of a rope during environmental testing cannot be easily instrumented without using a computer as a test vehicle. All recently manufactured flight ropes are being subjected to marginal temperature and voltage testing in a computer although this is not a requirement of the purchase specification. In addition, the flight ropes for Apollo 8 were subjected to vacuum test in a computer since they were installed in the system when the CM was subjected to vacuum testing. This problem has raised the question about the requirement to vacuum test the hardware. It seems there should be a requirement to vacuum test at least all hardware that may be installed in the spacecraft after the spacecraft vacuum tests, that is, spare subsystems and flight ropes.

The EL light failure mechanism is being investigated. To date the conclusion is that the glass strength is marginal in a spacecraft environment of vacuum and high temperature. In fact, assuming a distribution of breaking strength that is accepted for this type of glass, about 20 percent of the panels would be expected to break when subjected to the ICD limits of 150°F and vacuum.

Several fixes are being investigated, however. One possible approach not requiring a design change is to subject the panels to a screening test that stresses them beyond the worst-case flight environment thus eliminating all those that are not strong enough to survive the flight environment.

2. Provided support to the Apollo 7 and 8 missions in order to identify the causes of the anomalies that occurred during flight.

C. Documentation Changes

1. The LM ICD was rewritten by GAEC and reviewed by MIT

2. The drawings required to provide for the 14-legend IL panel were submitted to DRB and reviewed.

3. The Purchase Specification for the IDM modules was submitted to DRB but was not signed. The drawings were passed to NASA for further disposition. There were two reasons for not accepting these changes:

a) The documentation does not provide for identification of the spare modules that were subjected to the additional vibration.

b) The engineering tests are insufficient to verify that the relays are not damaged by the excessive vibration. A letter from AC Electronics to NASA (AP-M-21269-N3443) states that excessive vibration can damage a relay.

COMPONENT PROBLEMS

A. Diode Contact Problem

A new buy of diodes has shown a more severe failure rate during Flight Processing Specification processing. The problem has been investigated and a screen developed which appears to be adequate. The screen being used is a reduction of the V_F at 400 ma from 1.35V max to 1.20V max. The application of this screen to several lots has eliminated the excessive contact failures that were occurring. The analysis has indicated that most contact failures had a V_F at 400 ma of greater than 1.20V. This problem will be watched closely as the balance of the diodes are being processed through the FPS testing.

B. Flat Pack Contamination

This problem is continuing to make it difficult to vibrate computers without failures. In order to screen out the defective modules before computer vibration Raytheon has developed the equipment necessary to monitor module vibration. There have also been tests to develop the optimum vibration spectrum and level which will excite the particles. This has resulted in a vibration level of about 15g rms with a

flat spectrum between about 100 to 450 H_z. There is only limited experience with the module vibration; therefore, its effectiveness cannot yet be evaluated.

The tests conducted at MIT and at Raytheon have shown that the contamination does not move freely in the package. These tests show that the particles will adhere to the surfaces until the vibration level is high enough to dislodge them. Then they find a new stable position that may require even higher vibration levels to cause the particles to move again. The vibration level that the module is subjected to during computer vibration is sufficient to cause the particles to move but with a very low probability according to tests run at Raytheon. This explains the difficulty is making failures repeat during computer vibration.

3. Relay Vibration Test Plan

A test plan was generated which was designed to determine how long the relays could be vibrated to the FPS level without damage. This test has been discussed with MSC and a proposal is being submitted to authorize the testing.

SECTION 5

APOLLO GUIDANCE COMPUTER PROGRAMMING SUMMARY

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

Apollo 7 with Command-Service Module 101, the first manned Apollo test flight, was launched by AS-205 just after 11:00 am, EDT, 11 October 1968. It spent just short of 11 days in flight and orbited the earth 164 times. The crew, Schirra, Eisele, and Cunningham, worked hard and skillfully. All objectives were met and many additional tests were performed to confirm the excellence of the spacecraft.

MIT real-time mission support at KSC, Florida; at MSC, Houston; and at MIT/IL, Cambridge, played a prominent part in mission activities. Much was learned in how we can better support the more critical missions to come.

The service propulsion rocket was fired a total of eight times for a total velocity change in orbit of almost 3000 feet per second. Six of these burns were under control of the G&N steering and digital autopilot. The G&N monitored the other two SPS burns under backup system control as well as monitoring the Saturn-controlled boost into orbit.

During the first day, after separation from the launch vehicle, the spacecraft was given a couple of impulses from the reaction control jets to cause the vehicle to separate to a distance of about 100 miles ahead of the Saturn SIVB. From this point two SPS rocket burns were used to set up the conditions simulating the start of a CSM rescue of the Lunar Module in orbit using the SIVB as a target. The sextant was used by Eisele to insert the direction of the SIVB into the computer, operating with program "SUNDISK". No range data were available to help the rendezvous navigation because the planned ranging equipment will not be installed until a later spacecraft. Nevertheless, the computer converged upon good solutions. This may have been the first inflight use of Kalman estimation formulations. The maneuvers, using the reaction control jets, were made and rendezvous with the SIVB was cleanly accomplished.

The G&N system was turned on and off several times. Each time, the IMU realignment by the crew using star sightings was quickly and easily established. Several realignments separating long periods of operation of the IMU allowed the calculation of gyro drift. These measurements confirmed Dr. Draper's prognosis that the gyros will perform even better in space than prelaunch testing might lead one to predict.

The crew operated the onboard computer smoothly with practiced confidence. However, out of the extensive exercise of computer operations, three abnormal procedures during noncritical times caused the computer to "restart". Restart is a built-in protection to provide recovery from situations logically improper in the program. These events caused only a minor interruption in activity with no loss of memory or any other serious consequences. One other untested procedure was used which later inhibited the computer from accepting marks on star sightings. As with the restarts the cause and cure of this was quickly found by the team of MIT engineers who were on mission support duty.

The G&N hardware operated faultlessly with outstanding performance. One false alarm had us distressed early in the mission. One axis of the IMU did not register any acceleration at all for so long a period during non-thrusting flight that a short translation burn was executed to find out if the system was still working. It was. A very small deadband was apparently holding the accelerometer output at null on the axis receiving very small acceleration.

Navigation sighting attempts against earth landmarks at first caused trouble until the procedures were better defined. Then some accurate tracking data were obtained. Spacecraft onboard navigation has been demonstrated for the first time. Earth horizon navigation sightings were attempted briefly with no conclusive results due to the high orbital rate which will not occur in cislunar space. Some star counts and other subjective tests confirmed our visibility models of the optics. Stars could be seen in the daylight.

After the de-orbit burn, entry was started under manual control until the drag started to build up. Control was then switched to the G&N system. Many reports on the splash-down error from the target have been given. We know of no reason the miss should not have been less than a mile due to the G&N. I have no difficulty in believing the NASA position that the miss was only 1/3 of a mile.

SUNDANCE - MANNED LM (EARTH ORBITAL)

Level V testing of the SUNDANCE Program Rev. 306 was completed during the latter part of October 1968.

Mission "D"-type performance testing (Level VI) of the SUNDANCE Program is being conducted and is scheduled for completion to support the Software Flight Readiness Review (SERR) set for 20 January 1969.

The performance-type testing being run on SUNDANCE Rev. 306 falls into three major categories.

1. Engineer Simulations - MAC and ULTRAPAR.
2. AGC Performance Testing - Bit-by-Bit and Hybrid Simulation.
3. Mission Procedural Verification - Hybrid Simulation.

The simulations being conducted are using the current Mission Flight Plan for the various mission sequences being tested.

A total of 111 anomalies have been written since the FACI of SUNDANCE Rev. 292. Of the 111 approximately 46 of the anomalies were corrected in the re-release of SUNDANCE Rev. 306.

COLOSSUS - MANNED CSM (LUNAR CAPABILITY)

COLOSSUS 1 - Since the release of Rev. 237, MIT/IL has been performing performance-type testing (Level VI) for Mission C Prime. This effort was completed in mid-December 1968.

Preparation have been made for MIT/IL Flight Support and MIT/IL participation in some of the various simulation tests of the Mission Control Network for Mission C Prime. Flight support was given throughout the flight of Mission C Prime from the Cambridge facility and residents at KSC and MSC.

COLOSSUS 1A - During the reporting period many of the anomalies found on COLOSSUS 1 and several PCR's approved by the NASA/MSC Software Control Board were corrected and added to COLOSSUS 1A. COLOSSUS 1A, Rev. 249 was released for rope manufacturing on 28 October 1968 after retesting of the new assembly had been conducted. The COLOSSUS 1A program is presently in the midst of the performance testing phase (Mission D Level VI) which is scheduled for completion in mid-January 1969.

COLOSSUS 2 - The development of the COLOSSUS 2 program is in the Level III and Level IV testing phases. The major changes for COLOSSUS 2 are the fixing of anomalies found on COLOSSUS 1, 1A, and the addition of CSI/CDH targeting and the uprated DAP. The present planned release date for COLOSSUS 2 is the early part of February 1969.

LUMINARY - MANNED LM (LUNAR CAPABILITY)

During the reporting period Level III and IV testing were completed; a pre-FACI review was held the week of 12 November 1968 and the Formal FACI met on 5 December 1968. Revision 69 of the LUMINARY program was released to rope manufacturing on 26 November 1968. Since the release of LUMINARY the program has been undergoing Level V type testing which was completed in late December. Level V testing consists of re-running the majority of the Level III and IV tests on the released assembly in the case Rev. 69 of LUMINARY.

LUMINARY 1A - A joint NASA/MSC and MIT/IL meeting is schedule for the first week in January 1969 for the purpose of defining the contents and development schedule for a LUMINARY IA program. At present there are approximately 30 proposed PCR's that are to be considered in determining the base line definition of LUMINARY 1A.

TABLE 5.1

COLOSSUS CMC PROGRAM

FIXED MEMORY ALLOCATION CHART
(Actuals at Assembly Rev. 18)

I. Utility and Service Programs	
Interpreter, Single-Precision Subroutines, Fixed-Fixed Constant Pool	2206
Executive	337
Waitlist, Longcall	249
Interrupt Lead Ins	58
Interbank Communication	76
T4RUPT	791
SXT Angle Monitor	42
Keyrupt-Uprupt	68
Downlink Program and 5 Lists	404
Fresh Start and Restart	423
Alarm and Abort	85
Delayjob	30
Restart Routine and Tables	434
Phase Table Maintenance	179
Pinball Program and Noun Tables	2931
Displays, Priolarm	675
Program Select (V37, P00, R00)	308
Self Check	314
Extended Verbs	737
RTBOP Codes	181
SXTMARK	314
IMU Mode Switching	560
IMU Compensation	247
AGC Startup	32
AGC Power Down (P06)	47
IMU Status Check	17
Systems Test (P07)	551
Interpretive Constants	35
Flagup, Flagdown	59

GENTRAN	15
DAP Data Load (R03)	50
End Bank Markers	72
TOTAL UTILITY AND SERVICE PROGRAMS	12588

II. Autopilot and Maneuver Programs

Entry DAP	812
BOOST	65
RCS	1812
TVC	1420
TWINGIMB S40.6	70
TVNG	4
KALCMANU	713
Attitude Maneuver (R60)	86
Crew Defined Maneuver (R62)	11
Vecpoint	130
Rendezvous Final Attitude (R63)	41
Middle Gimbal Display	61
CM Body Attitude	195
TOTAL AUTOPILOT AND MANEUVER PROGRAMS	5420

III. Basic Math Routines

Inflight Alignment Routines	225
Powered Flight Subroutines	187
CSM Geometry	253
Time of Free Fall	268
Conic Subroutines	1062
Orbital Integration	1521
PERIAPO	78
Lattitude, Longitude, Altitude	159
Initial Velocity	174
Lunar and Solar Ephemeris	71
Planetary Inertial Orientation	204
TOTAL BASIC MATH ROUTINES	4202

IV. Targeting Routines

Transfer Phase Initiation Search	322
Coelliptic Sequence Initiation	672
Central Angles Subroutine	46
TOTAL TARGETING ROUTINES	1040

V. Navigation Routines	
Measurement Incorporation	385
Preferred Tracking Attitude (R61)	269
Lunar Landmark Selection (R35)	
Rendezvous Tracking Sighting Mark & Backup (R21, R23)	57
Rendezvous Tracking Data Processing & Backup (R22, R24)	492
Landmark Table	
TOTAL NAVIGATION ROUTINES	1203
VI. Powered Guidance Routines	
Servicer	375
Desired Thrust Direction (S40.1, S40.2, 3)	272
Cross Product Steering (S40.8)	129
VG Calculation (S40.9)	85
Time of Burn Calculation (S40.13)	79
Initial VG (S41.1)	14
Entry Guidance	1164
TOTAL POWERED GUIDANCE	2118
VII. Alignment Routines	
Coarse Align (R50)	75
Fine Align (R51)	111
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	980
VIII. Miscellaneous Programs and Routines	
P27 - Update Program	280
R36 - Rendezvous Out of Plane Display	129
P30 - P31 EXT DELTA V & General Lambert Maneuver	341
R05 - S Band Antenna Display	80
R30 - Orbit Parameter Display	283
R31 - R34 Rendezvous Parameter Display Routine 1 & 2	218
R33 - CMC/LGC Clock Synchronization	26
TOTAL MISCELLANEOUS PROGRAMS AND ROUTINES	1357

IX. Mission Control Programs

P01 - Prelaunch or Service Initialization	41
P02 - Prelaunch or Service Gyrocompassing	328
P03 - Optical Verification of Gyrocompassing	189
P11 - Earth Orbit Insertion Monitor	396
P17 - TPI Search	75
P20 - Rendezvous Navigation	135
P21 - Ground Track Determination	66
P22 - Orbital Navigation	957
P23 - Cislunar Midcourse Navigation	575
P32, P72 CSI Prethrust	99
P33, P73 CDH Prethrust	111
P34, P74 TPI Prethrust P35, P75 TPM Prethrust	654
P37 - Return to Earth	1312
P38, P78 SOR Prethrust P39, P79 SOM Prethrust	222
P40 - SPS Thrusting P41 - RCS Thrusting	780
P47 - Thrust Monitor	58
P51, P53 IMU Orientation Determination & Backup	256
P52, P54 IMU Realign and Backup	561
P61 - Maneuver to CM/SM Sep Attitude	309
P62 - CM/SM Sep and Pre-Entry Maneuver	91
P63 - Entry Initialization	20
P64 - Post 0.05G	6
P65 - Upcontrol	27
P66 - Ballistic	4
P67 - Final Phase	36
P76 - Target Delta V	96
P77 - LM TPI Search	1
TOTAL MISSION CONTROL PROGRAMS	7204
GRAND TOTAL	36112
REMAINING FIXED MEMORY	752

TABLE 5.2

LUMINARY LGC PROGRAM

FIXED MEMORY ALLOCATION CHART

(Actuals at Assembly Rev. 69)

I. Utility and Service Programs	
Interpreter, Single Precision Subroutines Fixed-Fixed Constant Pool	2211
Executive	345
Waitlist, Longcall	267
Interrupt Lead Ins	54
Interbank Communication	76
T4rupt (R10, R25)	634
Keyrupt-Uprupt	69
Downlink Program and 7 Lists	415
Fresh Start and Restart	466
Alarm and Abort	109
Delayjob	31
Restart Routine and Tables	314
Phase Table Maintenance	164
Pinball Program and Noun Tables	2969
Displays, Priolarm	702
Program Select Check (V37, P00, R00)	335
Self Check	314
Extended Verbs	735
RTB OP Codes	181
Radar Rupts	262
AOTMARK (R53)	423
Backup Marking (COAS)	16
IMU Mode Switching	564
IMU Compensation	282
LGC Startup	32
LGC Power Down (P06)	47
IMU Status Check	17
System Test (P07)	637
Interpretive Constants	35

Flagup, Flagdown	32
GENTRAN	15
DAP Data Load (R03)	169
Radar Subroutines	778
End Bank Markers	72
TOTAL UTILITY AND SERVICE PROGRAMS	13772

II. Autopilot and Maneuver Programs

Digital Autopilot	3345
KALCMANU	670
Find CDU W	441
Attitude Maneuver (R60)	99
Crew Defined Maneuver (R62)	11
Vecpoint	130
Rendezvous Final Attitude (R63)	65
Ball Angle Display	50
Middle Gimbal Display	57
TOTAL AUTOPILOT AND MANEUVER PROGRAMS	4868

III. Basic Math Routines

Inflight Alignment Routines	227
Powered Flight Subroutines	176
LM Geometry	99
Time of Free Fall	268
Conic Subroutines	1103
Orbital Integration	1500
PERIAPO	78
Latitude, Longitude, Altitude	159
Initial Velocity	182
Lunar and Solar Ephemeris	126
Planetary Inertial Orientation	204
TOTAL BASIC MATH ROUTINES	4122

IV. Targeting Routines

Coelliptic Sequence Initiation Constant Delta Altitude }	650
TOTAL TARGETING ROUTINES	650

V. Navigation Routines	
Measurement Incorporation	384
Preferred Tracking Attitude (R61)	125
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)	657
TOTAL NAVIGATION ROUTINES	1691
VI. Powered Guidance Routines	
Servicer (R12)	1201
Desired Thrust Direction (S40.1, S40.2, 3)	129
Cross Product Steering (S40.8)	66
VG Calculation (S40.9)	99
Time of Burn Calculation (S40.13)	105
Descent Guidance (R11, R13)	753
Throttle Logic	131
Ascent Guidance	546
TRIMGIMB (S41.1, S40.6)	44
TOTAL POWERED GUIDANCE ROUTINES	3074
VII. Alignment Routines	
Coarse Align (R50)	61
Fine Align (R51)	136
Auto Optics (R52)	65
Star Data Test (R54)	41
Gyro Torquing (R55)	27
Pick-A-Pair (R56)	132
Lunar Surface Sighting Routine	231
Star Catalog	223
TOTAL ALIGNMENT ROUTINES	916
VIII. Miscellaneous Programs and Routines	
R47 - AGS Initialization	138
R36 - Rendezvous Out of Plane Display	93
P27 - Update Program	270
P30 - External Delta V Prethrust	70
P31 - General Lambert Maneuver	61
R04 - RR/LR Self Test R77 - LR Spurious Return Test	188
R05 - S Band Antenna Display	118

R29 - Rendezvous Radar Flight Designate	333
R30 - Orbit Parameter Display	265
R31 - Rendezvous Parameter Display	177
R33 - CMC/LGC Clock Synchronization	27
R10 - Landing Analog Display Monitor	473
R11 - Abort Discretes Monitor	52
R13 - Auto Modes Monitor	41
TOTAL MISCELLANEOUS PROGRAMS AND ROUTINES	2306

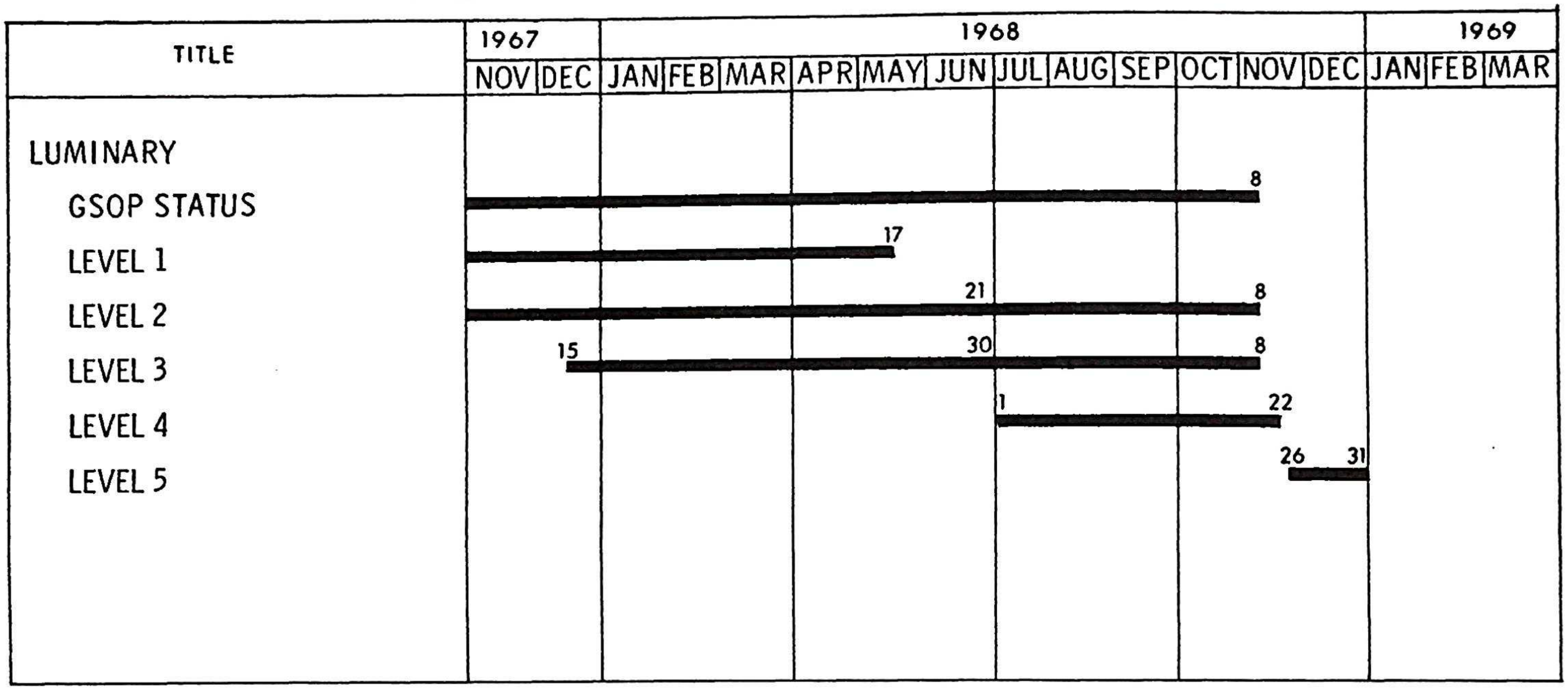
IX. Mission Control Programs

P12 - Ascent Guidance	201
P20, P22 - Rendezvous Navigation	374
P21 - Ground Track Determination	66
P25 - Preferred Tracking Attitude	40
P32, P72 - CSI Prethrust	91
P33, P73 - CDH Prethrust	140
P34, P74 - TPI Prethrust	652
P38, P78 - SOR Prethrust	230
P39, P79 - SOM Prethrust	
P40 - DPS Thrust	882
P41 - RCS Thrust	78
P42 - APS Thrust	22
P47 - Thrust Monitor	52
P51 - IMU Orientation Determination	263
P52 - IMU Realign	197
P57 - Lunar Surface Align	531
P63 - Landing Braking	181
P64 - Landing Approach	
P65 - Landing (AUTO)	45
P66 - Landing (ROD)	
P67 - Landing (Manual)	
P68 - Landing Conformation	---
P70 - DSP Abort	314
P71 - APS Abort	
P76 - Target Delta V	98
TOTAL MISSION CONTROL PROGRAMS	4457
GRAND TOTAL	35856
REMAINING FIXED MEMORY	1008

MIT/IL MASTER APOLLO SOFTWARE DEVELOPMENT PLAN

TITLE	1967		1968												1969		
	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
Mission "C" Prime (COLOSSUS Rev. 237)																	
GSOP STATUS														11			
Level 6 Coding & Testing										8 FACI (REV237)			8 CARR	15			
COLOSSUS IA Program (COLOSSUS Rev. 249 Mission "D")																	
Coding & Retesting										23		28 (RELEASED)					
GSOP STATUS (Sect. 3, 4, 5)														15			
Level 6 Testing													8		10		
SUNDANCE (Rev. 306 Mission "D")						24 FACI (REV292)			29 CARR (REV302)			15 (RELEASED) (REV306)			20 SFRR		
GSOP STATUS															17		
Level 6 Testing													8		13		
DAP Performance Testing						1								30			
COLOSSUS 2																	
GSOP STATUS													28		10		
Coding & Testing													28		7		

MIT/IL MASTER APOLLO SOFTWARE DEVELOPMENT PLAN



SECTION 6

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

E-1142 System Status Report, Rev. 59, October 1968.

E-2260 Guidance, Navigation, and Control Lunar Module Functional Description and Operation Using Flight Program LUMINARY, Vol. I, January 1969.

E-2333 Inertial Components Reliability and Population Statistics Report III, Martin Landey, December 1968.

E-2340 Abrasive Cutting of Thick-Film Conductors for Hybrid Circuits, J. Nugent, J.S. Palermo, October 1968.

E-2345 Software Configuration Management Plan, October 1968.

R-567 GSOP For Manned LM Earth Orbital and Lunar Missions Using Program LUMINARY, Section 2 Data Links (Rev. 1), October 1968; Section Digital Autopilot, December 1968; Section 5 Guidance Equations (Rev. 1), November 1968; Section 6 Control Data, November 1968.

R-577 GSOP For Manned CM Earth Orbital and Lunar Missions Using Program COLOSSUS 1 (Rev. 237), Section 2 Data Links (Rev. 2) November 1968.

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