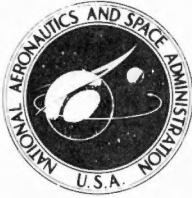


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FC4/R. A. Thorson
FC5/J. C. Bostick (3)
C. B. Parker
FC6/C. B. Shelley (3)
FM/J. P. Mayer
C. R. Huss
FS2/J. H. Alphin
FM13/R. P. Parten
FM13/GAC/G. Michos
FM2/F. V. Bennett
FM3/R. H. Brown
FM4/J. C. McPherson
FM5/R. L. Berry
FM6/E. C. Lineberry
R. R. Regelbrugge
FM7/R. O. Nobles
FS/L. C. Dunseith
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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS 77058

IN REPLY REFER TO: 70-FS55-71

APR 8 1970

MEMORANDUM TO: See list attached

FROM : FS/Chief, Flight Support Division

SUBJECT : Minutes of the LUMINARY 1C (LM131 Rev 1) Flight Software Readiness Review (FSRR) for the Apollo 13 mission

1. The LUMINARY 1C FSRR for the Apollo 13 mission was held on March 16, 1970, in building 2, room 966 in the morning and completed that afternoon in building 4, room 261. Mr. T. G. Price of the Flight Support Division (FSD) opened the meeting with a description of the agenda to be followed. The agenda is listed below along with the responsible organization for each presentation.

Erasable Load Status	Flight Software Branch (FSB)
TLOSS Presentation	FSB
Testing Report/Anomalies	MIT/SDL
FMES/FCI Testing Report	GAC
Crew Training Status	KSC

2. The first presentation was the erasable load status given by Mr. J. W. Jurgensen of FSD. There are two versions of the erasable load that are ready - one for LUMINARY 131 and one for LM131 Rev 1, depending on which flight program is flown. Two questions were raised. The altitude bias for the reasonability test for the LR may change but, at the present time, is set at 200 feet. Investigation is continuing. A discrepancy existed for the polarity of the LPD azimuth bias between an MIT/SDL memorandum and the correct value. The erasable memory load has the correct value.

3. The next presentation was given by Mr. J. R. Garman of FSD. Mr. Garman described the causes and effects of a computer cycle overload that is commonly referred to as TLOSS. Mr. Garman will write a memorandum describing the details of this presentation. The slides used for the presentation are included here as enclosure 1. Mr. Garman's conclusion was a recommendation to fly LM131 Rev 1.

4. The following presentation was given by Mr. R. A. Larson of MIT/SDL and consisted of a description of the Level 6 testing of both LUMINARY 131 and LM131 Rev 1 and finally a brief account of the outstanding anomalies. Mr. Larson also discussed what input to the LGC could cause TLOSS, what output of the LGC could cause TLOSS, and what actions could increase or decrease duty cycle. The slides from this presentation are enclosed as enclosures 2 and 3, respectively. Mr. Larson also recommended flying LM131 Rev 1.

5. Mr. S. Greene of GAC presented the results of the FMES/FCI testing. Mr. Greene stated that there were five outstanding Simulator Discrepancy Reports (SDR's) that are attributed to the software. Of the five, two are included in the official program notes for the Apollo 13 mission; one was decided not to be an anomaly by MIT/SDL, and GAC is to investigate further the remaining two. The content of Mr. Greene's presentation is enclosed as enclosure 4. Mr. Greene concluded that both LUMINARY 131 and LML31 Rev 1 are flight worthy.

6. Mr. F. Hughes of KSC then discussed the crew training status. He stated that the crew has flown numerous simulations and that they are ready regardless of whether LUMINARY 131 or LML31 Rev 1 is flown. He also said that the crew preference is LML31 Rev 1.

7. In conclusion, the opinion of all speakers at the meeting was that the LUMINARY 131 and LML31 Rev 1 rope configurations are both capable of flying the Apollo 13 mission and all preferred the LML31 Rev 1 rope configuration.

8. Action items assigned at the meeting and the responsible organizations are as follows.

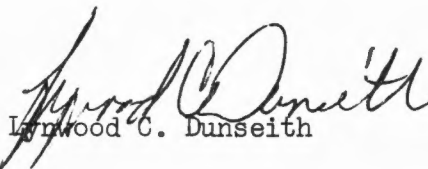
a. Determine value of altitude bias for the altitude reasonability test for the erasable memory load - FSB

b. Clarify workaround procedures for Apollo 13 descent programs to eliminate TLOSS problems - FSB

c. Official transmittal of Apollo 13 LM deorbit procedures - MIT/SDL

d. Investigate further and provide additional data for the SDR's discussed at the FSRR (LM-LUM-90, LM-LUM-91, LM-LUM-94) - GAC

9. Any questions may be directed to Mr. T. G. Price, LUMINARY Program Engineer, at extension 6247.


Lynnwood C. Dunseith

Enclosures 4

FS55:TGPrice:jvm

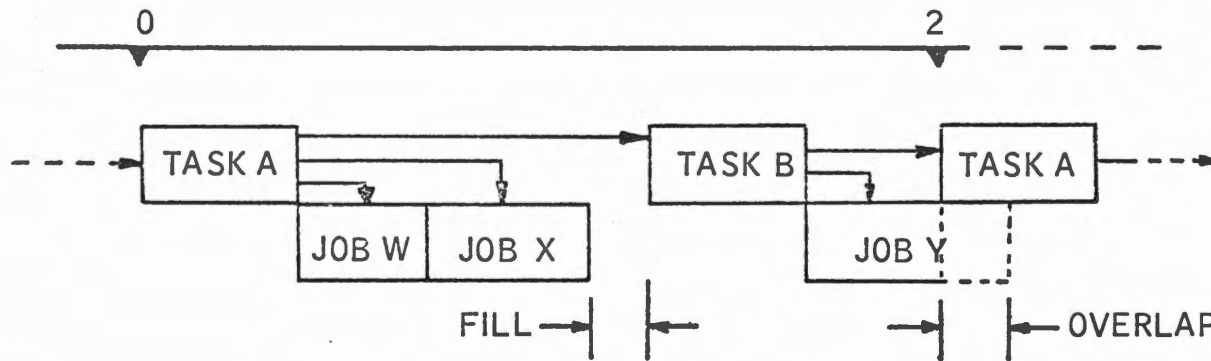
PERTINENT LGC CHARACTERISTICS

- I/O HANDLED THROUGH CP
- COMPUTATIONS PERFORMED BY PRIORITY (JOBS) OR TIME (TASKS)
- I/O TAKES ABSOLUTE PRIORITY OVER TASKS; TASKS OVER JOBS
- DESCENT COMPUTATIONS FORM A REPEATING 2 SEC CYCLE
- LGC "COMPUTES" AT 100 PERCENT OF ITS POSSIBLE RATE ALWAYS
- "FILL" COMPUTATIONS EXIST TO TAKE UP "DEAD TIME"

Enclure 1

DUTY CYCLE

- DUTY CYCLE IS THE PERCENTAGE OF TIME SPENT PERFORMING NON-FILLER COMPUTATIONS OVER A GIVEN PERIOD (2 SEC FOR DESCENT)
- COMP CYCLE OVERLAP CAN EXIST AT LESS THAN 100 PERCENT.



- HENCE THE CONCEPTS OF "PILING UP" AND "BENIGN OVERLAP"

TLOSS

- INCREASE IN DUTY CYCLE DUE TO NON-FILL COMPUTATIONS NOT EXPECTED DURING REAL DESCENT

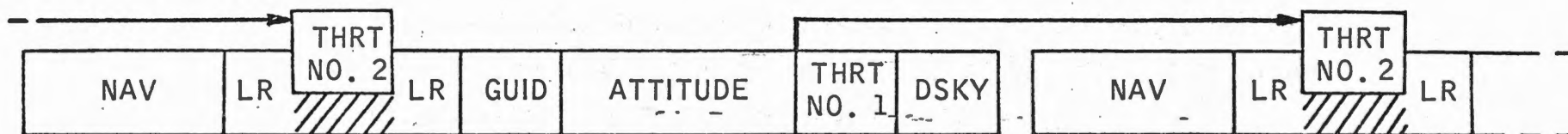
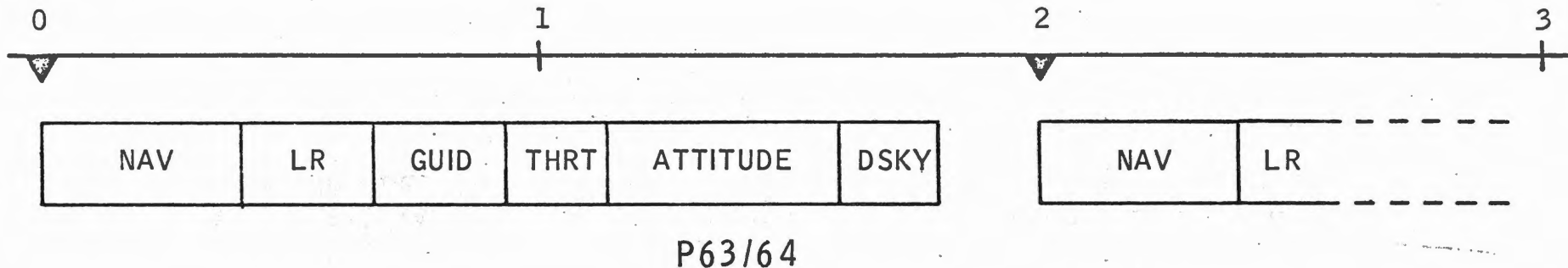
METHODS FOR FORCIBLY INTRODUCING TLOSS

- GAEC "UNFIXES" APOLLO 11 "FIX"
- M.I.T. HYBRID STOPS LGC PULSES
- M.I.T. ALL-DIGITAL INCREASES INSTRUCTION TIME
- ABNORMAL CREW INPUTS

POSSIBLE RESPONSES TO NEGATIVE MARGIN

(DUTY CYCLE > 100 PERCENT)

- GIVE UP
- SKIP (LOWER RATE)
- ALTERNATE COMPUTATIONS (FASTER, LESS ACCURATE)
- PILE-UP
- SOME COMBINATION



NOTE: OVERHEAD (DAP, TELEMETRY, T4RUPT, ETC.) NOT SHOWN

LURKERS

- IF COMPLETE SKIP OPERATION, LOSE FUNCTIONS IN REVERSE ORDER
- LGC HAS PROPERTY OF FIRST IN, FIRST OUT -- USUALLY
- HENCE "PILE-UP" CONSISTS OF OLD "LURKING" COMPUTATIONS (USUALLY ATT CMDS)

MAJOR PROBLEMS, TLOSS < 12 PERCENT

● ATTITUDE TRANSIENTS (LURKERS)

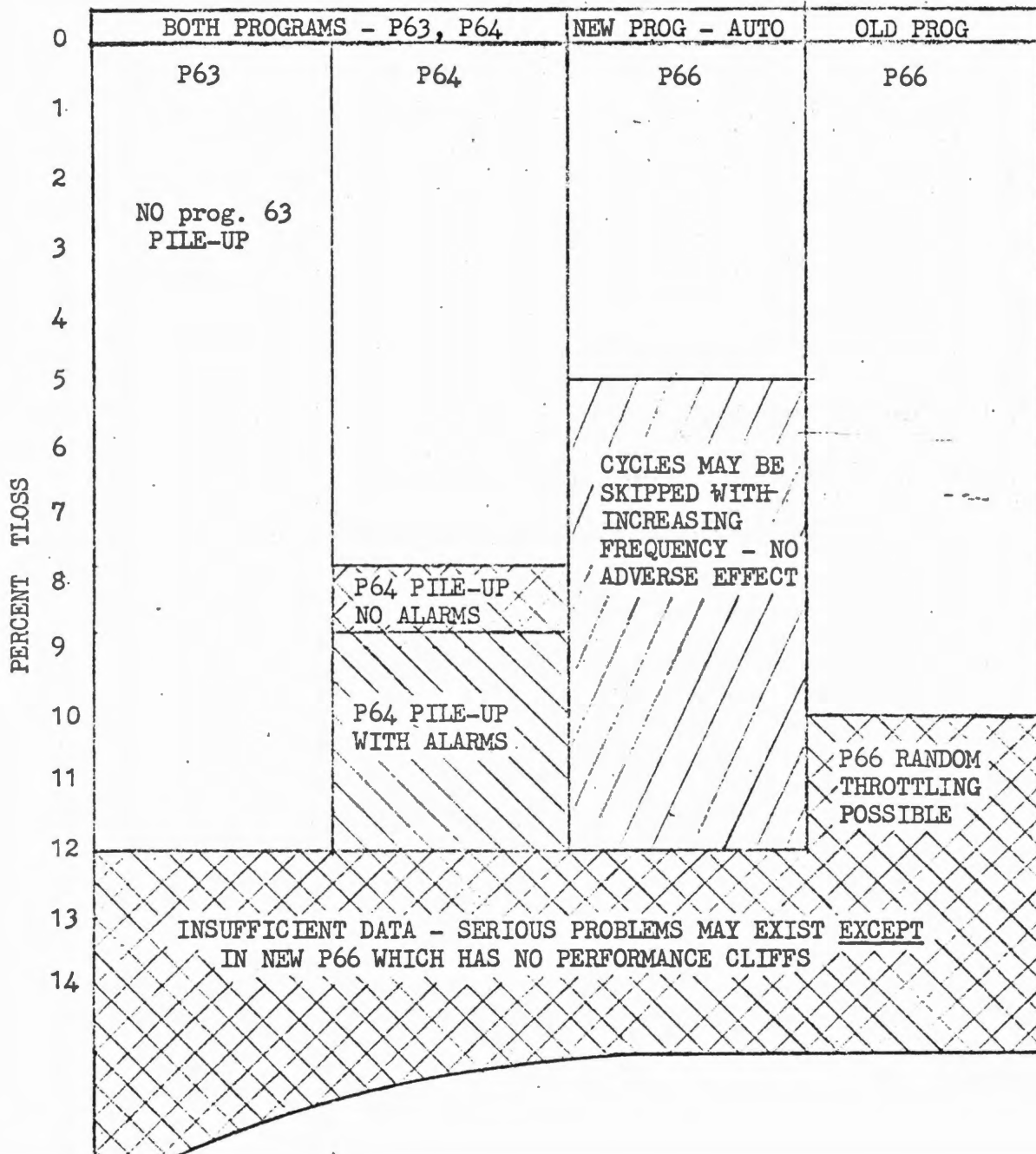
1. NEVER P63
2. P64 WITH NO WARNING, 8 TO 8.5 PERCENT BAND
3. P64 WITH WARNING (ALARMS) PROBABLE, 9 PERCENT OR GREATER
4. P64 TO P66 TRANSITION, AS IN "2" AND "3"

● RANDOM TRANSFER (CAN BE CATASTROPHIC TO LGC)

1. OCCURS AT P66 INITIATION
2. CAUSED BY ERASABLE CONFLICT IN A LURKER
3. RESTART (E.G. "BAILOUT") REQUIRED AT OR JUST PRIOR TO P66
4. TLOSS MUST BE GREATER THAN 8.5 PERCENT (TO GET RESTART)
5. WORKAROUNDS ARE AVAILABLE; SHOULD BE USED

● OLD PROGRAM (NO. 1) ONLY: RANDOM VIOLENT THROTTLING POSSIBLE IN P66

● NEW PROGRAM (NO. 2) ONLY: LOW PROBABILITY, NON-CRITICAL SINGLE CYCLE OF LOST DELTA-V



- TLOSS FIGURES BASED ON M.I.T. ALL-DIGITAL SIMULATOR
- OTHER SIMULATORS BASICALLY AGREE
- ZERO REFERENCE MAY BE IN ERROR

TYPICAL DUTY - CYCLE		
P63	77-82	80-85
P64	90	90
P66	75	95
P70/71	?	80-82
	OLD PROG	NEW PROG

CONCLUSIONS

1. IN NEW (NO. 2) PROGRAM, ONCE SAFELY IN P66, NO ADVERSE BEHAVIOR POSSIBLE UP PAST 12 PERCENT. GRACEFUL DEGRADATION BEYOND 12 PERCENT.
2. IN OLD (NO. 1) PROGRAM, EVEN WITHOUT AUTO CAPABILITY, RANDOM AND VIOLENT THROTTLING CAN OCCUR IN P66 AT AROUND 10 PERCENT TLOSS -- EVEN IF GOT INTO P66 SAFELY.
3. BOTH PROGRAMS (NO. 1 AND NO. 2) HAVE ATTITUDE TRANSIENT AND RANDOM TRANSFER PROBLEMS. A PREVENTATIVE WORK-AROUND SHOULD BE USED FOR THE LATTER.
4. OTHER NON-CRITICAL PROBLEMS AND STRANGE BEHAVIOR HAVE BEEN OBSERVED BY SIMULATORS ON BOTH PROGRAMS; THERE ARE SURELY MORE UNKNOWN PROBLEMS IN BOTH.
5. PROGRAM NO. 2 FIXES A KNOWN PROBLEM IN P66 AND MAKES P66 SAFE (NO PERFORMANCE CLIFFS). PROGRAM NO. 2 IS RECOMMENDED.
6. IT IS CURRENTLY FELT THAT SOME REAL-TIME MONITORING OF TLOSS ON APOLLO 13 BY THE GROUND IS POSSIBLE. IT IS RECOMMENDED THAT SUCH MONITORING BE USED, AT MOST, TO TELL THE CREW NOT TO PERFORM A RANDOM TRANSFER WORK-AROUND.
7. FOR THE FUTURE, THE FOLLOWING ACTION ITEMS SHOULD BE LEVIED, PERHAPS ON THIS GROUP:
 - A. CLARIFY PROPOSED H-2 PROCEDURES
 - B. GENERATE A PCR TO PROVIDE A REAL-TIME-TO-SIMULATION CALIBRATION TECHNIQUE
 - C. GENERATE A PCR WHICH WILL ELIMINATE PERFORMANCE CLIFFS DUE TO TLOSS IN DESCENT; DO THIS REGARDLESS OF HOW MUCH MARGIN IS GAINED BY OTHER MEANS

MIT/IL PRESENTATION FOR THE
MISSION "H-2" APOLLO 13
FLIGHT SOFTWARE READINESS REVIEW

HELD AT NASA/MSC ON 16 MARCH 1970

End...

CONTENTS

- SECTION I CSM COLOSSUS 2D (MANCHE72 Rev 3)
- A. Summary of COLOSSUS 2D Development
 - B. PCR/PCNs and Anomalies Incorporated
 - C. Performance Testing
 - D. RTCC Testing
 - E. Procedural Testing
 - F. STG Testing
 - G. Documentation Review
 - H. Anomalies Existing
 - J. MIT Recommendations
- SECTION II LM LUMINARY 1C (LM131 Rev 1)
- A. Summary of LUMINARY 1C Development
 - B. PCR/PCNs and Anomalies Incorporated
 - C. Performance Testing
 - D. RTCC Testing
 - E. Procedural Testing
 - F. STG Testing
 - G. Documentation Review
 - H. Anomalies Existing
 - J. MIT Recommendations

SECTION I

CSM PROGRAM

SUMMARY OF COLOSSUS 2D DEVELOPMENT

Establishment of a COLOSSUS 2D Assembly	18 July 1969
Release of COLOSSUS 2D for Rope Manufacture	
COMANCHE 72	20 Oct. 1969
MANCHE72 Rev 3	12 Dec. 1969
Completion of Mission "H-2" Level 6 Testing	12 March 1970*
Completion of Mission "H-2" RTCC Testing	11 March 1970
Total Number of PCR/PCNs Accomplished in the COLOSSUS 2D Release	11
Total Number of Anomalies Fixed in the COLOSSUS 2D Release	8

*Pending completion of Takeover and Normal Boost Cases.

COLOSSUS 2D PCR/PCNs IMPLEMENTED

806.1 Allow N07 to Address Output Channels.
863.1 Make P76 Set NODO Flag.
936.1 Initialize V90 Time to TIG.
962 Describe Error Check in P23. (GSOP)
963 R52-delete 407 Alarm and Drive Trunnion to 50°.
965 Define POOFLAG. (GSOP)
966 Clear Preferred Orientation Flag in P40/41.
977 Alignment Star Aberration Alogorithm Change. (GSOP)
980 Termination of R60. (GSOP)
984 Avoid Coarse Align during Saturn. (MANCHE72 Rev 3)
992 T6JOB OPCODE Correction. (GSOP)

ANOMALIES FIXED IN COLOSSUS 2D

- COM 21 Backwards Integration Can Occur in P27 Uplink.
- COM 22 V79, V41, V55, V42, do not Perform CCS' New Job.
- COM 24 Coding in Iterator.
- COM 26 Extended Verb 92 Flagword 6 is changed while job is
not in Inhint.
- COM 27 V32E Response to FLV16N45 in P37 Results in
Indeterminate Program Transfer.
- COM 29 N70 Instead of N71 Display in P23.

COLOSSUS 2D
PERFORMANCE TESTING

Boost Takeover during Polynomials.*

Normal Boost to Orbit, P52, R04.

DOI

CSM Active from Insertion (LM in 10 nm. x 45 nm. Orbit).

CSM Passive from Insertion (LM in 10 nm. x 45 nm. Orbit).

CSM Active from Insertion (LM in 10 nm. x 45 nm. Orbit) - Optics Only.

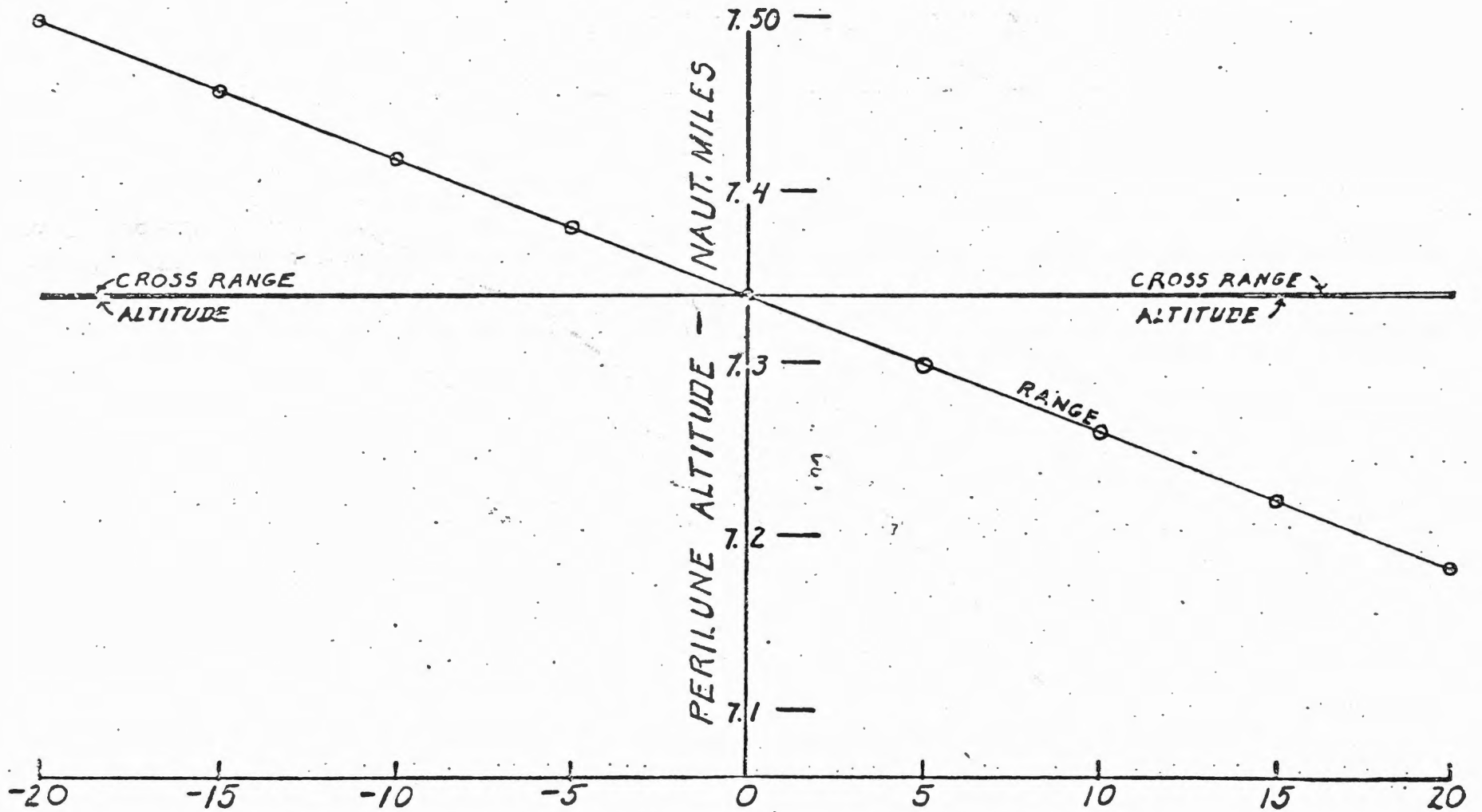
CSM Active from Insertion (LM in 10 nm. x 45 nm. Orbit) - VHF Only.

RTE (EI-30 Hours to Splash).

RTE (Post TEI-abort, No Comm., P23, P37/P40/P41 after Sphere
Crossing to Splash).

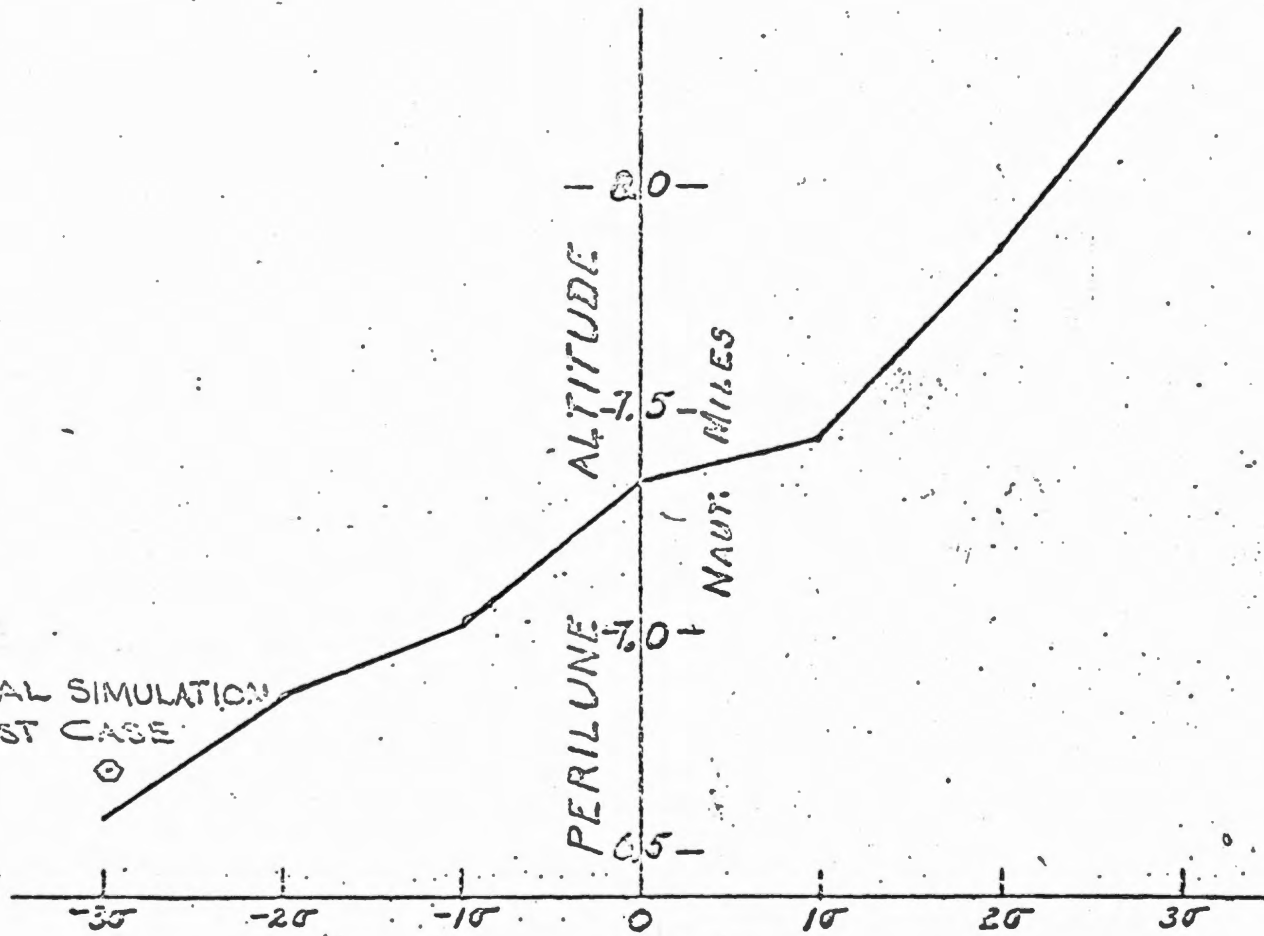
Nominal Lunar Entry.

*Also run with Apollo 12-type Glitches.



POSITION ERROR AT IGNITION - THOUSANDS OF FEET
EFFECT OF POSITION ERROR AT DOI ON PERILUNE

ALL DIGITAL SIMULATION
3 σ WORST CASE



IMU ERRORS (INCLUDING MISALIGNMENT)
EFFECT OF IMU ERRORS ON PERILUNE DURING DOI

COLOSSUS 2D
MISSION "H-2" RTCC TESTING

Large Translunar Midcourse Correction (Earth Centered P30/P40).

Lunar Orbit Insertion (LOI, P30/P40).

Descent Orbit Injection (DOI, P30/P40).

Uplinks (All CMC Command Loads).

P11 Boost REFSMMAT, Nominal Liftoff.

P11 Boost REFSMMAT, 1-hour Late Liftoff.

P51 Alignment Determination #1.

P51 Alignment Determination #2.

Nominal Hi-speed Lunar Entry.

Lo-speed Deorbit Entry.

COLOSSUS 2D
SPECIAL MIT BOOST RUNS*

- #0 Reference Run: Nominal Takeover and V46 during Polynomials.
- #1 180° CDUZ Glitch at 45 sec; Takeover at 50-sec., V46 20 sec. later.
- #2 Takeover at 50 sec., 180° CDUZ Glitch at 55 sec., V46 15 sec. later.
- #3 -180° CDUX Glitch at 45 sec., Takeover 5 sec. later.
- #4 Takeover and V46 at 20 sec., 180° CDUZ Glitch at 30 sec., 90° CDUZ Glitch at 70 sec.
- #5 V48 for NODAP, 90° CDUZ Glitch at 70 sec., Takeover and V46.

*Documentation for these runs is presented in Colossus Memo #262: Special Boost Glitch Testing on Colossus 2D (MANCHE72 Rev 3), by O.S. Eliassen. Simulation and edit printouts and plot material are on file at MIT.

COLOSSUS 2D
SPECIAL ENTRY RUNS

MSC Requested Entry Runs (1575 nm, 1550 nm, 1600 nm Range).

MSC Requested Runs:

- #1 Nominal Entry
- #2 Steep Entry
- #3 Deorbit Entry
- #4 Long Range Entry
- #5 Shallow High Speed Entry
- #6 Initially Lift Down Short Range Entry
- #7 Special UPCTRL-Exit Entry
- #8 Ultra High Speed Entry

COLOSSUS 2D
MISCELLANEOUS DOCUMENTATION

Colossus Memo #246 Apollo 12 Pre-CSI CSM Rendezvous Navigation.
(E. Muller/P. Kachmar)

Colossus Memo #247 Procedures for Avoidance of Apollo 12 Pre-CSI CSM
Rendezvous Navigation Problem. (E. Muller/P. Kachmar)

Colossus Memo #259 Apollo 13 DOI Level 6 Perturbation Analysis.
(E. Hume/C. Beals)

Colossus Memo #262 Special Boost Glitch Testing on Colossus 2D (MANCHE72
Rev 3). (O. S. Eliassen)

STG MEMO #1450 STG LEVEL 5 TESTING OF COLOSSUS 2D (G. EDWARDS)

COLOSSUS 2D
MISSION PROCEDURAL TESTING

P37 RTE

LOI

CSM DOI

LM Initiation, Undocking and Separation

P22 Landing Site Tracking

CSM Circularization

CSM Lunar Orbit Plane Change

Post-Insertion to TPF

Post-Insertion to TPF - Non-nominal

TEI

High Velocity Entry

COLOSSUS 2D
MISSION PROCEDURAL TESTING

P37 RTE: Longitude Control (Outbound)	Tests completed; no procedural problems.
LOI:	Tests completed; no procedural problems.
DOI:	Tests completed; no procedural problems.
P22 LM Tracking: (8 um x 60 nm Orbit)	Tests completed; no procedural problems.
CSM Lunar Orbit Circularization:	Tests completed; no procedural problems.
CSM Plane Change #1 Coarse & Fine Align:	Tests completed; no procedural problems.
Gyro Torquing:	Tests completed; no procedural problems.
Rendezvous, Insert to TPF Nominal, LM Active:	Tests completed; no procedural problems.
Nominal, CSM Active:	Tests completed; no procedural problems.
Non-nominal, CSM Active (10 fps Out-of-plane)	
CSI, PC, CDH Sequence:	Tests completed; no procedural problems.
Forced node at MCC2:	Tests completed; no procedural problems.
TEI:	Tests completed; no procedural problems.
High Velocity Entry:	Tests completed; no procedural problems.

REFERENCES FOR H2 MISSION
PROCEDURAL VERIFICATION TESTING

1. Apollo 13 Mission O.T. Simulator Data Package #69-FM13-611, 12 December 1969 (12 March 1970 Liftoff).
2. Revision 1 to Apollo 13 Mission O.T. Simulator Data Package #70-FM13-58, 17 February 1970 (11 April 1970 Liftoff).
3. CSM Rendezvous Procedures, H1 Mission, Final Rev A, 14 October 1969.
4. LM Rendezvous Procedures, H1 Mission, Final, 26 September 1970.
5. Apollo 13 Preliminary CMP Solo Book, 6 February 1970.
6. Apollo 13 CSM G&C Checklist, 5 January 1970.
7. Apollo 13 Preliminary Flight Plan, 6 February 1970.
8. Mission H2 Flight Readiness Test Prelaunch Erasable Load for MANCHE72 Rev 3, #70-FS55-12, 10 January 1970.
9. Apollo 13 LM Lunar Surface Checklist, 16 February 1970.
10. LM Descent/Ascent Procedures, Mission H, Final, 23 September 1969.

COLOSSUS 2D
SYSTEM TEST LAB TESTING

Extended Verbs

IMU Operational Programs

IMU Performance Test

IRIG Scale Factor

Prelaunch Alignment

Special P11/Gimbal Lock

COLOSSUS 2D
SYSTEM TEST LAB FINAL TEST

AREAS TESTED

1. Change in Gimbal Lock Protection Portion of T4RUPT to Prevent Coarse Align in P11.
2. IMU Performance and IRIG Scale Factor Test.
3. Prelaunch Alignment.
4. IMU Control Extended Verbs and Control Programs.

COLOSSUS 2D
DOCUMENT REVIEW CHRONOLOGY

1. CSM 109 Flight Data File

Systems Checklist, dated 1/5/70, received 1/9/70.

Malfunction Procedures, dated 1/5/70, received 1/9/70.

CSM Systems Data, dated 1/12/70, received 1/23/70.

Update, dated 2/9/70, received 2/17/70.

CSM Cue Cards, dated 1/26/70, received 2/2/70.

Update, dated 2/20/70, received 3/3/70.

CSM Entry Checklist, dated 1/5/70, received 2/2/70.

CSM Launch Checklist, dated 1/5/70, received 2/2/70.

CSM G&C Checklist, dated 1/5/70, received 2/2/70.

CMP Solo Book, dated 2/6/70, received 2/19/70.

CSM Rescue Book, dated 2/16/70, received 2/27/70.

Informal transmittal of comments, 2/24/70 - 3/9/70. Review not completed on all documents.

2. CSM Procedures Documents

CSM 109 AOH Vol. 2, dated 1/14/70, received 2/9/70.

Informal transmittal of comments, 2/9/70 - 3/10/70.

Formal Transmittal (POPC 505-511), dated 3/13/70.

The inclusion of information related to software changes which updated COM 67 to COM 72 has been assured.

ANOMALIES EXISTING IN COLOSSUS 2D
(MANCHE72 Rev 3)

<u>Anomaly</u>	<u>Description</u>	<u>Disposition</u>
COM 31	RENDWFLG not reset correctly in P23.	Fix for 2E. Program note for 2D.
COM 32	Constant error in AUGEKUGL.	Fix for 2E.
COM 33	Coding error in KALCMANU steering.	Fix for 2E. Program note for 2D.
COM 34	LONGCALL POODOO exit errors.	Fix for 2E. Program note for 2D.
COM 35	Downlink state vector may be $\bar{0}$ after sphere crossing.	Fix for 2E. Program note for 2D.
COM 36	Erroneous state vector and W-matrix while in P00.	Fix for 2E. Program note for 2D.

CONCLUSION

BASED ON THE PRECEDING
DATA, MIT/CSD LABORATORY
RECOMMENDS THE USE OF
COLOSSUS 2D (MANCHE72 Rev 3)
FOR MISSION "H-2".

SECTION 2

LM PROGRAM

SUMMARY OF LUMINARY 1C DEVELOPMENT

Establishment of a LUMINARY 1C Assembly	15 Aug. 1969
Release of LUMINARY 1C for Rope Manufacture	
Rev 130	5 Nov. 1969
Rev 131	3 Dec. 1969
LUM131 Rev 9	14 Jan. 1970
LM131 Rev 1	4 Feb. 1970
Completion of Mission "H-2" Level 6 Testing	12 March 1970
Completion of Mission "H-2" RTCC Testing	13 March 1970
Total Number of PCR/PCNs Accomplished in the LUMINARY 1C Release	16
Total Number of Anomalies Fixed in the LUMINARY 1C (LM131 Rev 1) Release	9

LUMINARY 1C PCR/PCNs IMPLEMENTED

285 Remove Check of Auto Throttle Discrete.
806.2 Allow N07 to Address Output Channels.
846
(Rev 1) More Accurate DELTA-T TAILOFF for P70.
863.2 P76 Set NODO Flag.
882 Replace VHORIZ with FORVEL.
893 Abort Targeting Flagbit.
895 V59E Allow Use of LR in Position #2 in P63.
936.2 Initialize V90 Time to TIG.
942 LR Update Cutoff (Accomplished as Part of PCR 988).
943 Velocity Reasonability Test.
968 LPD Bias.
971 Change Fixed Memory Constant (APS) DELTA-T TAILOFF
972 Display Polarity of Sighting Angle Difference in R54.
976 Erasable Program for LM Deorbit.
988 Auto P66 Implemented (LUM131 Rev 9).
1013 Multiply Servicicers Avoidance in P66 (LM131 Rev 1).

ANOMALIES FIXED IN LUMINARY 1C

- LNy 75 Radar Self Test Routine.
- LNy 92 V41 and V42 do not Perform CCS New Job before Final Display.
- L-1B-01 Selection of P22 before CSM is within RR Coverage.
- L-1B-03 Quantity COEFFR Discrepancy when 1JACCQ and 1JACCR are Equal.
- L-1B-04 During Descent Switching RR Mode into LGC and Out Disables Meter.
- L-1B-05 R60 Mode II Attitude Errors Placed in FDAI Needles before Desired Attitude.
- L-1B-09 If a Restart Occurs during a Radar Read, the following Radar Read may be Incorrect.
- L-1B-10 Rate and Attitude Overshoot will be Observed after ACA is required.
- L-1C-02 For Early Abort from PDI Locations of a VAC Area are Destroyed.

LUMINARY 1C
PERFORMANCE TESTING

LM131 Rev 1 Level 4 TLOSS		5% TLOSS Level 6		
		LUMINARY 131	LUM131 Rev 9	LM131 Rev 1
	<u>Rendezvous</u>			
5%	Nominal LM Active w/P52 Alignment	X	X	X
	<u>Aborts from Descent</u>			
5%	Abort at 30K ft-Insertion to CSI Solution w/P20 Navigation	X	X	X
	Abort at 7K ft-Insertion to CSI Solution w/P20 Navigation	X	X	X
	Abort after Touchdown - Insertion to CSI Solution w/P20 Navigation	X	X	X
9.5%	Abort at 46K-ft			X
	Abort Stage at 46K-ft			X
	<u>Lunar Surface Operation and Ascent</u>			
5%	(Offset RLS to Show Effect of Gravity Vector Updates to RLS) (Initialized with 5° Pitch, 15° Yaw) P68, P00, P12, P57 (2 Stars), P06, P57 (Gravity/Star) P57 (Gravity/REFSMMAT), P22, P12, P20, P32	X	X	X
	<u>Landing (Prime Site)</u>			
5%	Automatic Landing - V59 just Prior to HIGATE P66 Landing with Following Redesignations	X	X	X
	N69: 10K/5K ft; ACA: None	X	X	X
9.5%	N69: 20K/20K ft; ACA: 2 + AZ/2 - EL	X	X	X
	N69: None; ACA: 2 - AZ/2 + EL	X	X	X

LUMINARY 1C
MISSION "H-2" RTCC TESTING

APS Abort (P30/P42).
 DPS Abort (P30/P40).
 Uplink Test (All LGC Command Loads).
 NOM CSI (P32).
 Preturbed CDH (P33).
 Preturbed TPI (P34).
 Preturbed TPI (P34).
 Two Star Alignment (P57).
 Star/g -vector Alignment (P57).

LUMINARY 131	LUM131 Rev 9	LM131 Rev 1
0	0	X
0	0	X
0	0	X
0	0	X
0	0	X
0	0	X
0	0	X
0	0	X

LUMINARY 1C
MISSION PROCEDURAL TESTING

	LUMINARY 131	LUM131 Rev 9	LM131 Rev 1
Docked DPS DOI ABORT	0	0	0
Docked APS DOI ABORT	0	0	0
PDI (50,000') to Landing - Auto	0	1	2
PDI (50,000') to Landing - ROD	0	2	1
PDI (50,000') to Landing - Redesignate	0	4	1
PDI (30,000') to Landing - Auto	0	2	2
PCI (30,000') to Landing - ROD	0	3	2
PDI (30,000') to Landing - Redesignate	0	1	1
PDI (70,000') to Landing - Auto	0	2	0
PDI (70,000') to Landing - ROD	0	3	1
PDI (70,000') to Landing - Redesignate	0	4	1
DPS Abort from Descent (PDI at 50,000)	0	0	2
DPS-APS Abort from Descent (PDI at 50,000')	0	1	2
DPS Abort from Descent (PDI at 30,000')	0	2	1
DPS-APS Abort from Descent (PDI at 30,000')	0	3	2
DPS Abort from Descent (PDI at 70,000')	0	2	2
DPS-APS Abort from Descent (PDI at 70,000')	0	1	1
DPS Abort from 2nd Pass Descent (PDI at 30,000')	0	0	0
DPS-APS Abort from 2nd Pass Descent (PDI at 30,000')	0	0	0
Abort State from Surface	0	0	2

continued...

LUMINARY 1C
Mission Procedural Testing, cont'd.

	LUMINARY 131	LUM131 Rev 9	LM131 Rev 1
DPS Abort from 2nd Pass Descent (PDI at 30, 000')	0	0	0
DPS Abort from 2nd Pass Descent (PDI at 70, 000')	0	0	0
Surface Alignments (P57).	0	0	1
Surface Tracking (P22)	0	0	2
Pre-liftoff to Rendezvous	0	1	0
Ascent Liftoff to Insertion	4*	0	1
Post-insertion to Rendezvous	0	0	2**
Post-insertion to Rendezvous Non-nominal	0	0	0
Pre-TPI to Rendezvous	0	0	0
LM Deorbit.	0	0	1

NOTES:

*3 on LUM131 Rev 2; 1 on LUM131 Rev 1.

**1 Linked.

The above procedural testing was conducted
with no T-LOSS.

LUMINARY 1C
MISSION PROCEDURAL TESTING

Docked DPS burns (LOI & DOI Aborts):	Low priority run.
Auto P66 Landings:	Run from PDI Altitudes of 30,000, 50,000, and 70,000 feet, all nominal.
ROD P66 Landings:	Run from PDI Altitudes of 30,000, 50,000, and 70,000 feet, all nominal.
Redesignation Landings:	Run from PDI Altitudes of 30,000, 50,000, and 70,000 feet, all nominal.
N69 Landing Site Revision:	Combined with P66 and redesignation landings.
Aborts from Powered Descent:	Initiated from landings with PDI at 30,000, 50,000, and 70,000 feet, both DPS and DPS-APS aborts, all nominal.
Abort from Surface:	Nominal run.
Surface Activities:	Nominal runs using P57 and P22.
Ascent:	Nominal run.
Re rendezvous from Post- Insertion:	Nominal run, also linked run done with off-nominal burns but good rendezvous.
LM Deorbit:	Nominal run.

NOTES:

- (1) All runs listed are without TLOSS. TLOSS testing (approximately 30 runs)
- (2) For references (Documents), refer to page C-13.

LUMINARY 1C
SYSTEM TEST LAB TESTING

IMU Performance Test

IRIG SF Test

AGS Align Test

Radar Test

LUMINARY 1C
SYSTEM TEST LAB FINAL TEST

AREAS TESTED

1. Several Radar Program Portions where Changes were made.
2. IMU Performance Test and IRIG Scale Factor Test.
3. AGS Align Test.

LUMINARY 1C
DOCUMENT REVIEW CHRONOLOGY

1. LM Flight Data File

Rendezvous Charts, dated 12/24/69, received 1/9/70.

Update, dated 2/16/70, received 2/20/70.

Data Card Book, dated 1/12/70, received 1/19/70.

Update, dated 2/20/70, received 3/2/70.

G&N Dictionary, dated 1/5/70, received 1/19/70.

Update, dated 2/13/70, received 2/20/70.

Cue Cards, dated 1/19/70, received 1/23/70.

Update, dated 2/4/70, received 2/17/70.

Systems Data, dated 1/12/70, received 1/23/70.

Contingency Checklist, dated 1/6/70, received 1/29/70.

Update, dated 2/13/70, received 2/25/70.

LM Time Line Book, dated 2/16/70, received 2/25/70.

Malfunction Procedures, dated 2/6/70, received 2/17/70.

Activation Checklist, dated 2/16/70, received 2/19/70.

Lunar Surface, dated 2/16/70, received 2/20/70.

Informal transmittal of comments, 3/11/70. Review not completed on all documents.

(continued...)

LUMINARY 1C
Document Review Chronology, cont'd.

2. LM7 Procedures Documents

AOH Vol. 2, dated 1/14/70, received 2/4/70, reviewed 2/28/70.

Informal transmittal of comments; No new comments.

Comments based on LUM 1C (Rev 131) were submitted for LM6 AOH on 1/19/70. With these comments, the inclusion of information in the LM7 AOH related to software changes which updated LUM116 to LUM131 has been assured.

ANOMALIES EXISTING IN LUMINARY 1C
(LM131 Rev 1)

<u>Anomaly</u>	<u>Description</u>	<u>Disposition</u>
L-1B-11	Terminal mass error.	Fix for 1D.
L-1C-01	Delta-V increment may be subtracted twice from V_G , following a restart.	Fix for 1D. Program note for 1C.
L-1C-03	Routine LRPOS2 is called by a TC, but it returns via SWRETURN.	Fix for 1D.
L-1C-04	Two REMODE tasks operating simultaneously.	Fix for 1D (PCR 990). Work around for 1C.
L-1C-05	Sign disagreement when HCALC is calculated with RVBOTH.	Fix for 1D. Program note for 1C.
L-1C-06	P40, P42 or P63 commanding ullage, with average-g off.	Fix for 1D. Program note for 1C.
L-1C-07	Erroneous state vector and W-matrix while in P00.	Fix for 1D. Program note for 1C.

INPUT TO LGC WHICH CREATES T-LOSS

<u>Name</u>	<u>TL/Unit</u>	<u>Max Rate (PPS)</u>	<u>Max T-LOSS</u>
X PIPAS	1 MCT/Pulse	3200	3.75%
Y PIPAS	1 MCT/Pulse	3200	3.75%
Z PIPAS	1 MCT/Pulse	3200	3.75%
X IMU CDU	1 MCT/Pulse	6400	7.50%
Y IMU CDU	1 MCT/P lse	6400	7.50%
Z IMU CDU	1 MCT/Pulse	6400	7.50%
S RADAR CDU	1 MCT/Pulse	6400	7.50%
T RADAR CDU	1 MCT/Pulse	6400	7.50%
RHC X	1 MCT/Pulse	192/3200	
RHC Y	1 MCT/Pulse	192/3200	
RHC Z	1 MCT/Pulse	192/3200	
LR Data	6/2 Sec.	3200	.05% Gated
U/L	2 MCT/Pulse	1000	
D/L	2 MCT/End Pulse	50	
ROD	2 MCT/Count		

Envelope 3

OUTPUT OF LGC WHICH CREATES T-LOSS

<u>Name</u>	<u>TL/Unit</u>	<u>Max Rate (PPS)</u>	<u>Capacity</u>	<u>Max T-LOSS</u>
GYRO CNTR	1 MCT/Pulse	3200	8192 PPS/Burst	3.75%
CDU CMD X	1 MCT/Pulse	3200	292/600 MSEC	3.75%
CDU CMD Y	1 MCT/Pulse	3200	292/600 MSEC	3.75%
CDU CMD Z	1 MCT/Pulse	3200	292/600 MSEC	3.75%
CDU CMD S	1 MCT/Pulse	3200	384/500 MSEC	3.75%
CDU CMD T	1 MCT/Pulse	3200	384/500 MSEC	3.75%
CDU CMD X	1 MCT/Pulse	3200	< 384 MAX	3.75%
CDU CMD Y	1 MCT/Pulse	3200	< 384 MAX	3.75%
CDU CMD Z	1 MCT/Pulse	3200	< 384 MAX	3.75%
CDU CMD S	1 MCT/Pulse	3200	< 384 MAX	3.75%
CDU CMD T	1 MCT/Pulse	3200	< 384 MAX	3.75%
THRUST	1 MCT/Pulse	3200	3200/SEC.	3.75%
ALT/ALT RATE	1 MCT/Pulse	3200	3200/SEC.	3.75%

ACTIONS WHICH INCREASE DUTY CYCLES

1. Monitor	7%
2. VXXNXXE	7%
3. PRO	1%
4. KEYREL	5%

ACTIONS WHICH DECREASE DUTY CYCLES

1. ATT HOLD	2-4%
2. DAP OFF	15-20%
3. LR NO READ	10%
4. V58	1%
5. DID	3%
6. MAN THROT	0%
7. V59 (Limited to P63)	8% (for approx. 10 sec.)

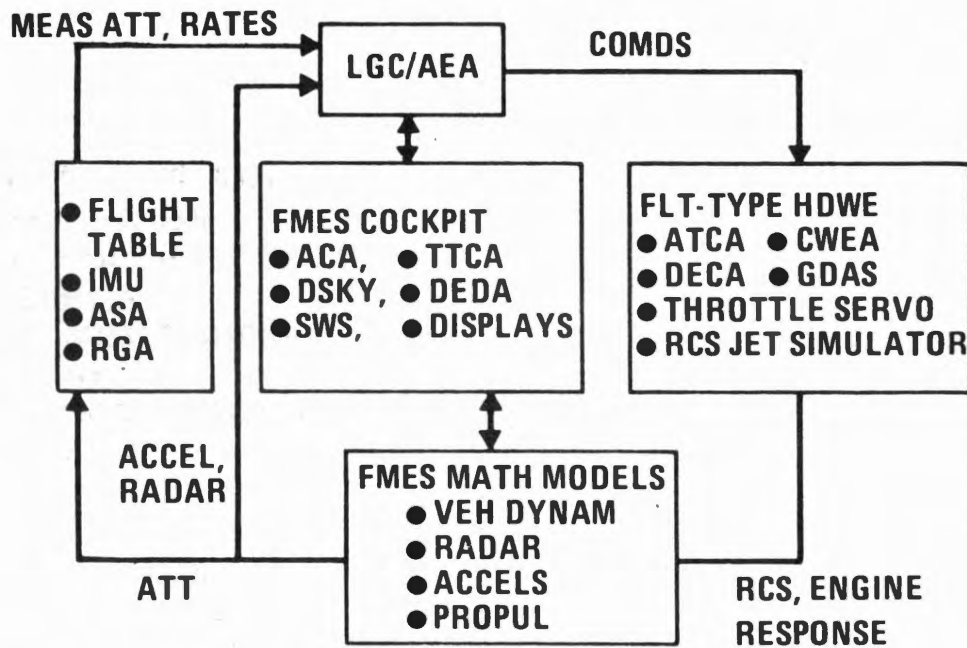
3

FMES/FCI

H2 - MISSION TESTS



FMES/FCI FUNCTIONAL FLOW



SCOPE OF TESTS

<u>NOMINAL MISSION</u>	<u>LUM 131 R.9</u>	<u>LUM 131A R.3 (LM131)</u>	<u>LUM 131</u>
CSM CIRC (P52, P76, P20)	✓	✓	✓
PDI - AUTO LANDING (P63, P64, P65/66)	✓	✓	✓
PDI - ROD LANDING (P63, P64, P66)	✓	✓	✓
PDI - AUTO P66 WITH ROD (P63, P64, P66)		✓	
ASCENT THRU MCC I (P12, P20, P32, P33, P34, P35, P41)	✓	✓	✓
PDI - AUTO LANDING, USING P27	✓		
PDI - LPD - ROD LANDING (P63, P64, P65)	✓		
DEORBIT (P30, P42)		✓	✓

SCOPE OF TESTS

SOFTWARE CHECKS

TLOSS

	<u>LUM 131</u> <u>R.9</u>	<u>LUM 131A</u> <u>R.3 (LM131)</u>	<u>LUM 131</u>
- PDI, AUTO LDG	✓ (5)	✓ (3)	✓ (2)
- PDI, ROD LDG	✓ (2)	✓ (2)	✓ (1)
- POWERED ASCENT	✓		
- EARLY AND LATE ABORT			✓ (2)

RESTARTS

- PDI, AUTO LDG	✓		
- PDI, ROD LDG	✓		
- ASC THRU MCCI	✓	✓	✓

**OTHER TESTS OF
AUTO P66**

✓

P22 TEST

✓

ABORTS - EARLY & LATE

✓

✓

SCOPE OF TESTS

REDLINE TESTS

LUM131 REV 9

PDI, LR LOCKED IN POS 1	✓
PDI, LR LOCKED IN POS 2	✓
LR REASONABLENESS CHECK	✓
PDI, LR CAPABILITY ERRORS, TO AUTO LDG	✓
P20, RR BORESIGHT ERROR	✓
SLOW ENGINE START TRANSIENTS - P63, P12, P40, P42	✓

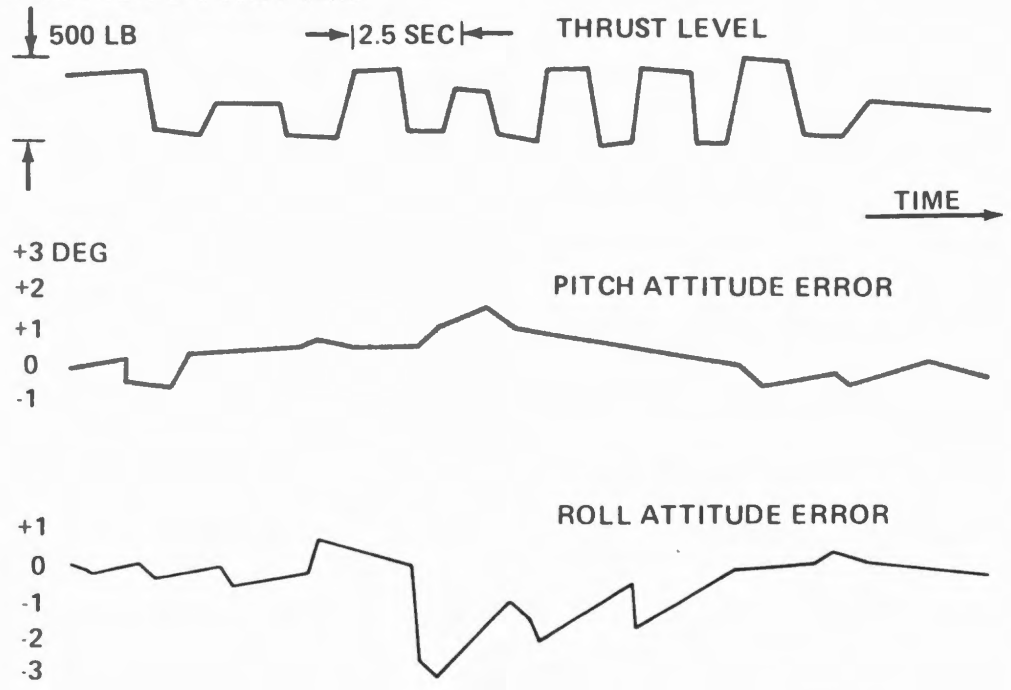
LM 131 P66

FORWARD AND LATERAL HORIZONTAL VELOCITIES

RUN H20T - 4.2 #3

TIME (HR/MIN/SEC)	FORWARD VELOCITY (FPS)			LATERAL VELOCITY (FPS)	
	FMES	LGC		FMES	LGC COMPUTED
		DSKY	COMPUTED		
108/3/16.7	2.3	0.6	2.0	-2.7	-3.3
3/17.7	2.4			-2.8	
3/18.7	2.4	0.6	2.1	-3.0	-3.6
AUTO → 3/19.7	2.4	0.6		-3.1	
3/20.7	2.5		2.2	-3.2	-3.7
3/21.7	2.3	0.6		-3.0	
3/22.7	2.1		1.8	-2.6	-3.3
3/23.7	1.8	0.6		-2.1	
3/24.7	1.5		1.1	-1.4	-2.1
3/25.7	1.2	0.0		- .7	
3/26.7	1.0		.5	- .1	- .9

P66 AUTO PROFILE



TLOSS TESTS

LUM 131

RUN NO.	% TLOSS	TYPE OF TEST	A/C AND NO. OBSERVED		
			P63	P64	P65/66
H2-131-11.1#1	9.5	AUTO LAND	31201(3)	31201(2)	NONE
H2-131-11.2#1	9.5	ROD (ATT. HOLD)	31201(3)	NONE	NONE
H2-131-11.3#1	9.5	PDI+196 ABORT	NONE	N/A	N/A

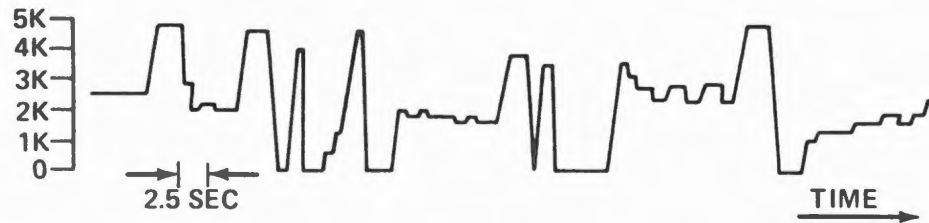
LM 131

H20T-6.8#1	9.5	ROD AUTO	NONE	31201(1)	NONE
H20T-6.9#2	5	AUTO	NONE	NONE	NONE
H20T-6.11#2	9.5	ROD(ATT. HOLD)	31201(2)	NONE	NONE
H20T-6.12#4	9.5	AUTO	NONE	NONE	NONE
H20T-6.13#2	5	ROD(ATT. HOLD)	NONE	NONE	NONE

TLOSS THROTTLE PROFILE, LUM 131 REV 9

THRUST VS TIME

ATT HOLD P66, 9.5% TLOSS



AUTO P66, 9.5% TLOSS



LGC TAPE METER OUTPUTS, FT/SEC (EVERY ½ SEC)

<u>TLOSS</u>	<u>TLOSS</u>	<u>RESTART</u>
-81.5	-35	-62.0
-80.0	-35	-63.5
▶ -75.5	▶ -26.5	▶ -58.0
-81.0	-34.5	-64.0
-81.5	-36.5	-62.0
-81.5	-36.5	-63.5
▶ -78.0	▶ -28.0	-64.0
-81.0	-36.0	
-81.5	-36.5	
-81.5	-37.5	
	▶ -28.0	
	-37.0	
	-37.0	
	-38.0	
	▶ -28.5	
	-38.5	

ALTITUDE RATE
TAPE HAS
1 FPS INCREMENTS

**FMES/FCI SIMULATOR DISCREPANCY REPORTS
6 JAN-10 MAR 1970**

TYPE	QTY	PROG CHG	RESOLUTION FOR H-2			STATUS	
			PROG NOTE	PROCED OR REPAIR	NOT LM-7 PRIME PROBLEM	CLOSED	OPEN
HARDWARE	0	0	—	—	—	—	—
SOFTWARE	8	2	1	1	8	4	5
SIMULATOR	6	0	—	5	6	6	0
TOTAL	14	2	1	6	14	10	5

CONCLUSIONS

**A SUCCESSFUL NOMINAL OR ABORT LM-7 MISSION
CAN BE FLOWN USING EITHER LM 131 OR LUM 131
WITH APPROPRIATE WORKAROUND PROCEDURES.**

PROBLEM AREAS

<u>LUM 131</u>	<u>LM 131</u>	<u>COMMENTS</u>
	✓ P66 HORIZONTAL VELOCITY DISPLAYS	WORKAROUND AVAILABLE X
JET FIRENGS IN P65		WORKAROUND AVAILABLE
TLOSS P63, P64 EFFECTS (TAPE METER)	✓ TLOSS P63, P64 EFFECTS (TAPE METER) LM-LUM-91	SYMPTOMS NOT UNSAFE X
1301 ALARM IN PLANE CHANGE P41	✓ 1301 ALARM IN PLANE CHANGE P41 LM-LUM-90	NOT UNSAFE X
HARDWARE RESTARTS AFFECTING P20 RR UPDATES	OK ✓ HARDWARE RESTARTS AFFECTING P20 RR UPDATES	WORKAROUND AVAILABLE ✓
X-AXIS OVERRIDE ALTITUDE QUANTIZATION	X-AXIS OVERRIDE ALTITUDE QUANTIZATION	NOT UNSAFE
STEP IN THROTTLE RECOVERY	STEP IN THROTTLE RECOVERY	NOT UNSAFE
AZBIAS POLARITY ERROR	AZBIAS POLARITY ERROR	FIX PADLOAD VALUE

OK → (circled) FIX PADLOAD VALUE

???