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MIT/CSDL PRESENTATION FOR THE
MISSION "J-2" APOLLO 16
FLIGHT SOFTWARE READINESS REVIEW

HELD AT NASA/MSC ON 7 March 1972

CSM PROGRAM

SUMMARY OF COLLOSSUS 3 DEVELOPMENT

Establishment of a COLOSSUS 3 Assembly.....8/ 7/ 69

Release of COLOSSUS 3 for Rope Manufacture.....3/ 1/ 71
Artemis Rev 72 FACI.....3/ 3/ 71

Completion of Mission "J-2" Level 6 Testing.....3/ 6/ 72

Completion of Mission "J-2" RTCC Testing.....2/ 1/ 72*

Total Number of PCR/ PCNs Accomplished in
the COLOSSUS 3 Release.....116 (Note 1)

Total Number of Anomalies Fixed in
the COLOSSUS 3 Release..... 16

*Uplink Tests

Note 1: PCR/ PCNs accomplished for COLOSSUS 3 = 60.

E-LOAD DIFFERENCE

Level 6 performance tests used E-load J2KSTA with exceptions as noted below

ERASABLE	REASON FOR CHANGE
FLAGWRD 1	N0D0P01 Flagbit set to 1
FLAGWRD 8	CMOONFLG, LMOONFLG, SURFFLAG modified as required
FLAGWRD 3	REFSMFLG modified as required
TEPHEM	Align to mission timeline
REFSMMAT	
IMU Comp.	for 1σ errors
DAPDATR 1	
DAPDATR 2	
RMAX	for rendezvous
VMAX	for rendezvous
ETDECAY	for powered flight
PACTOFF	via V48
YACTOFF	via V48
CSMMASS	via V48 and P40
LAT (SPL)	For entry
LNG (SPL)	For entry

COLOSSUS 3
PERFORMANCE TESTING

Normal Boost to Orbit, P52, Apollo 16 Data Package, Digital

TLI with P15 Cutoff Apollo 16 Data Package, Digital

M = 1, CSM Active, dual sensor tracking, Apollo 16 Data Package, Digital

M = 1, CSM Active, dual sensor tracking, Apollo 16 Data Package, Ultra Par

M = 1, plus Bailout, CSM Active, dual sensor tracking, Apollo 16 Data Package, Digital

M = 1, plus Bailout, CSM Active, dual sensor tracking, Apollo 16 Data Package, Ultra Par

RTE (Post TEI abort, No Comm, P23/P37/P40/P41 after Sphere Crossing to splash, Apollo 16 Data Package

Nominal Lunar Entry, Apollo 16 Data Package

Low Orbit P24 Landmark Tracking

LOI-Docked SPS Burn

TEI-CSM SPS Burn

DOI-CSM SPS Burn

- TEST CASES
  - M = 1
    - CSM ACTIVE
    - SXT + VHF TRACKING
    - BEGIN TRACK AT INS + 6 MIN.
  - M = 1 + LM BAILOUT
    - LM ACTIVE FOR CSI, CDH
    - CSM ACTIVE FOR TPI AND MCC'S
    - SXT + VHF TRACK TO TPI
    - COAS + VHF TRACK POST TPI

- NOTES OF INTEREST

  - IN THE M = 1 CSM ACTIVE CASE, N49's OCCURRED ON THE THIRD AND FIFTH MARKS (BIT-BY-BIT) WITH THE 1σ MSFN STATE ERRORS. IT SHOULD BE RECOGNIZED THAT THERE IS A GOOD POSSIBILITY THAT N49's COULD OCCUR FOR A FEW MARKS PAST THE FIFTH ONE WHEN TRACKING IS INITIATED SEVERAL MINUTES AFTER INSERTION WITHOUT A STATE VECTOR UPLINK.

  - INERTIAL STATE ERRORS CAN CAUSE FAIRLY SIZABLE VARIATIONS IN THE TPI ELEVATION ANGLE FOR THE M = 1 CASE (TPI OCCURS 47 MIN AFTER INSERTION) WITH RESULTANT CHANGES IN THE IN-PLANE NORMAL VELOCITY REQUIRED. TRACKING PERFORMANCE IS ESSENTIALLY INDEPENDENT OF ELEVATION ANGLE.

- CONCLUSIONS FROM LEVEL 6 TESTING
  - THE COLOSSUS 3 RENDEZVOUS SYSTEM (NAVIGATION AND TARGETING PROGRAMS) OPERATED CORRECTLY AND ITS SYSTEM PERFORMANCE IN ACHIEVING A SUCCESSFUL RENDEZVOUS WAS GOOD.

COLOSSUS 3
MISSION PROCEDURAL TESTING

1. TLI (P15 Logic Test)
2. Return to Earth Targetting (P37)
   a. Transearth
3. Cislunar Navigation
   a. Translunar
4. SPS Thrusting
   a. LOI
   b. DOI
   c. TEI
5. Landmark Tracking
   a. P24 (High Orbit and Low Orbit)
6. Rendezvous (MINKEY)
   a. CSM Active (M = 1)
   b. CSM Active (CFP from Bailout)
7. Entry
   a. Short Range (1188 nm)
   b. Long Range (1800 nm)
   c. Orbital Plane with High Angle of Inclination

NOMINAL VICE SHORT RANGE
10 60

COLOSSUS 3
DOCUMENT REVIEW

I CSM Flight Data File

G and C Checklist	Dated 12/8/71, received 1/9/72
Launch Checklist	Dated 12/13/71, received 1/10/72
System Data	Dated 12/3/71, received 12/2/71
Rescue Book	Dated 12/14/71, received 12/29/71
System Checklist	Dated 12/9/71, received 12/17/71
Malfunction Procedures	Dated 12/21/71, received 1/10/72
CSM Updates	Dated 11/15/71, received 11/19/71
Entry	Dated 12/6/71, received 12/28/71
Contingency Checklist	Dated 12/7/71, received 12/20/71

II Crew Procedures Documents

Apollo Operations Handbook Vol 2	Dated 10/1/71, received 11/16/71

Comments to the above listed documents are being transmitted via telecon to NASA/MSC (CF22, CF34) as they develop.

TVC DAP CONTROL

OF THE

CSM/LM ASCENT CONFIGURATION

FSRR

7 MARCH 1972

MSC / HOUSTON

THE PROBLEM

- CERTAIN LOI ABORT PROCEDURES CALL FOR THE TVC DAP TO CONTROL THE OFF-NOMINAL CSM/LM ASCENT CONFIGURATION (VARIOUS PROPELLANT LOADINGS).

- BOTH THE CSM AND THE CSM/LM AUTOPILOTS HAVE BEEN EXAMINED FOR THEIR CONTROL CAPABILITY.

- THE RECOMMENDATION IS TO USE THE CSM AUTOPILOT FOR ALL CSM AND LM PROPELLANT LOADINGS PROVIDED CERTAIN BENDING REQUIREMENTS CAN BE VERIFIED.

MAJOR CONSIDERATIONS

1) RIGID-BODY STABILITY

2) PROPELLANT SLOSH STABILITY

3) BENDING STABILITY

4) ENGINE TRANSIENT DUE TO ATTITUDE-ERROR INITIALIZATION AT IGNITION

1. RIGID-BODY STABILITY

- EITHER THE CSM OR THE CSM/LM AUTOPILOT CAN HANDLE THIS CONFIGURATION.
- CSM DAP GAIN ERRORS DUE TO MASSPROP CALCULATIONS WILL BE LESS THAN ABOUT -38% (-2.5 dB) MAXIMUM.
- CSM DAP GAIN MARGIN (+10, -15 dB) IS SUFFICIENT TO COVER THIS ERROR.

2. PROPELLANT SLOSH STABILITY

- CSM/LM DAP CANNOT PROVIDE SLOSH STABILIZATION FOR ANY APS LOADING WHEN THE CSM IS LIGHTLY LOADED (LM APS AND CSM SUMP TANK SLOSH FREQUENCIES EXCEED THE CSM/LM DAP STABILIZATION RANGE DUE TO HIGH VEHICLE ACCELERATION)

- CSM DAP CAN PROVIDE ADEQUATE STABILIZATION FOR THE SLOSH FREQUENCIES EXPECTED FOR ALL VEHICLE LOADINGS.

- THERE IS THE POSSIBILITY OF AN UNSTABLE SLOSH MODE IN THE SPS SUMP TANK WITH EITHER DAP WHEN THE CSM IS HEAVILY LOADED. IF THIS OCCURS IT SHOULD NOT BE SERIOUS, AS THE DIVERGENCE TIME CONSTANT WILL BE LARGE, AND THE TANK GEOMETRY SHOULD ACT TO DAMP THE OSCILLATIONS.

3. BENDING STABILIZATION

- BASED ON MSC DATA FOR THE CSM/ LM (ASCENT EMPTY) CONFIGURATION, THE LOWEST BENDING FREQUENCY IS ESTIMATED TO BE IN THE RANGE OF 4 - 5.5 CYC/ SEC .

- IN THIS FREQUENCY RANGE THE NOMINAL CSM RIGID-BODY GAIN-PHASE LOCUS IS DOWN AT LEAST 60 dB FROM 0 dB. UNCERTAINTIES IN DAP GAIN AND ACTUATOR DYNAMICS CAN REDUCE THIS MARGIN TO ABOUT 50 dB.

- ALLOWING AN ADDITIONAL 10 dB MARGIN, THE BENDING REQUIREMENTS FOR STABILITY ARE:
    1) FREQUENCY OF AT LEAST 4 CYC/ SEC
    2) RESONANCE PEAK OF 40 dB OR LESS ABOVE THE RIGID-BODY GAIN-PHASE LOCUS AT THE BENDING FREQUENCY

- VERIFICATION OF THE ACTUAL BENDING BEHAVIOR NEEDS FURTHER DATA AND ANALYSIS.

4. ENGINE TRANSIENT

- CSM DAP PICKS UP RCS ATTITUDE ERRORS AT IGNITION TO INITIALIZE THE DAP FILTER. THESE ERRRORS SHOULD BE LESS THAN 1 DEGREE, AS RCS DAP USES THE 0.5 DEG DEADBAND TO TIG.

- THE LEAD COMPENSATION IN THE DAP FILTER PRODUCES AN AMPLIFIED COMMAND TO THE ENGINE— THIS COMMAND COULD BE AS LARGE AS 4-6 DEG.

- THE ENGINE DYNAMICS DO NOT ALLOW THE ENGINE TO RESPOND FULLY TO THE COMMAND TRANSIENT, SO THAT THE ENGINE EXCURSION WILL NOT EXCEED 2 DEG.

- WE HAVE NO DATA ON THE BENDING LOADS DUE TO SUCH A TRANSIENT.

CONCLUSIONS

- THE CSM/LM AUTOPILOT CANNOT PROVIDE SLOSH STABILITY FOR THE CSM/LM ASCENT CONFIGURATION

- THE CSM AUTOPILOT CAN CONTROL THIS CONFIGURATION, PROVIDED CERTAIN REQUIREMENTS ON BENDING MODE BEHAVIOR ARE MET. THESE ARE:
  1) LOWEST BENDING FREQUENCY OF AT LEAST 4 CYC/SEC
  2) BENDING RESONANCE PEAK OF 40-dB OR LESS ABOVE THE RIGID-BODY GAIN-PHASE LOCUS AT THE BENDING FREQUENCY

- THE ENGINE TRANSIENT AT IGNITION MAY BE ABOUT 1-2 DEG. IT IS DESIRABLE TO HAVE AN ESTIMATE OF THE BENDING LOADS DUE TO THIS TRANSIENT.

ANOMALIES EXISTING IN COLOSSUS 3

COM 43	Entry Overshoot	Program Note
COM 54	Periodic DOWNRUPT losses during CSM-Alone P40 TVC	Program Note
ART 01	Do not initiate P31-P36 or P79 while AVEG is running if P20 Rendezvous is not already enabled	Program Note
ART 02	Incorrect value of NN displayed in N55 in P32 during multiple CSIs if NN is greater than 4	Program Note
ART 03	Selection of P47 during P20 will destroy N78 and low half or AGEOFW	Program Note
ART 05	CANCELLED	
ART 06	The HAFLAG, which is used to determine whether the CSI subroutines were called by P31 or P32, is not cleared by P31 until just prior to display of N90	Program Note
ART 07	If P34, 35, 74 or 75 is selected and is allowed to proceed past the V06N81 final comp display, selection of any other (PRE-TPI) MINKEY Targetting Program will result in incorrect data for the following P76, and incorrect auto-W-Matrix initialization sequencing	Program Note

ANOMALIES EXISTING IN COLOSSUS 3 (continued)

ART 08	Option 2 of P20 does not operate correctly in ATTHOLD	Program Note
ART 09 Rev 1	P24 may update landmark pointing using garbage data	Program Note
ART 10	Selection of P40/41 with P20 running results in P40/41 attitude maneuver with R03 deadband	Program Note
ART 11	Incorrect landmark updating in P24, when P20 options 1 or 5 is running in the background	Program Note
ART 12 Rev 1	Option 1 of P20 will not operate correctly for stars (Star Code = 1 - 45) within 10^0 of desired spacecraft vector	Program Note
ART 13 Rev 1	DEADBAND not centered about present attitude when program requests minimum DEADBAND if HOLDFLAG negative	Program Note
ART 14	After CMC has stopped an auto-maneuver due to CDUZ exceeding 75^0, any manual maneuver to an attitude with CDUZ still greater than 75^0, putting RHC back in detent causes CMC to drive spacecraft back to its original position	Program Note

ANOMALIES EXISTING IN COLOSSUS 3 (continued)

ART 15	A restart during the "comp cycle" following a response to V16N45 locks out R61 and R52 until the "comp cycle" is finished	Program Note
ART 16	Bypass of first R60 in P79 followed by V58E may wipe out R31. If PRO is entered for 2nd R60, V06N18 may also disappear from DSKY	Program Note
ART 17	P79 is not correctly restart protected	Program Note
ART 18	It is possible for R22 to process an R23(COAS) generated mark as a sextant mark if a restart occurs after the ENTR response to the V53N45 display, and before the next mark is taken	ProgramNote

STATUS OF ERASABLE MEMORY PROGRAM (EMP) FOR APOLLO 16

	Description	Status *
CEP 001	Software restart initiated by V31 (EMP 502)	6
CEP 011	Shortened P23 (EMP 514	3
CEP 104	(1) Inhibit Gimbal Lock Monitor Downmoding (EMP 509) (2) P40 Termination During Average G When EMP 509 is operating (EMP 512)	6 4
CEP 107	Enter P51 With IMU Discrete Failed (EMP 521)	2
CEP 108	Entry With a Failed CDU (EMP 513)	1
CEP 115	Recovery from Restart During Plane Change Pulse Torquing (EMP 518)	3
CEP 117	GDC REFSMMAT Determination (EMP 503)	5
CEP 201	DSKY Display of VHF Range During P79 (EMP 506)	6
CEP 203	Manual Range Input (EMP 515)	3
CEP 302	Landmark Tracking with Failed MARK/MARK REJ Button (EMP 501)	6
CEP 303	Backup Optics Variance (EMP 504)	6
CEP 304	Mark Taking with Mark Button Failure (EMP 505)	3
CEP 305	Landmark Tracking with Frozen Optics (EMP 508)	5

STATUS OF ERASABLE MEMORY PROGRAM (EMP) FOR APOLLO 16 (continued)

CEP 306	Landmark Tracking with Datalink Failure or Unusable Optics (EMP 500)	5
CEP 310	Convert Optics Shaft and Trunnion Angles to Body Angles (EMP 517)	4
	Digital Event Timer Goes DSKY (EMP 519)	2
	Enter MINKEY at Post Plane Change Pulse Torquing (EMP 520)	3
	P40 with Failed Optics CDUs (EMP 522)	2

*
1. Not Started
2. In Work
3. Draft Version Submitted to NASA
4. First Official Submitted to NASA
5. Final Version Submitted to NASA
6. NASA Approved/Flight Qualified

CONCLUSION

BASED ON THE PRECEDING DATA,
MIT/CSD LABORATORY RECOMMENDS
THE USE OF COLOSSUS 3
(ARTEMIS 72) FOR MISSION "J-2"

FSRK
3-7-72
MIT - LARSON

MIT/ CSDL PRESENTATION FOR THE
MISSION "J-2" APOLLO 16
FLIGHT SOFTWARE READINESS REVIEW
HELD AT NASA/ MSC ON 7 March 1972

LM PROGRAM

SUMMARY OF LUMINARY 1E DEVELOPMENT

Establishment of a LUMINARY 1E Assembly.....9/ 21/ 70

Configuration Control..... 12/ 23/ 70

Release of LUMINARY 1E for Rope Manufacture
Rev 210.....3/ 22/ 71
FACI Meeting..... 3/ 3/ 71

Completion of Mission "J-2" Level 6 Performance Testing 3/ 6/ 72

Completion of Mission "J-2" Level 6 Procedural Testing 4/ 15/ 72

Completion of Mission "J-2" RTCC Testing 2/ 25/ 72

Total Number of PCR/ PCNs Accomplished in the LUMINARY 1E Release..... 52

Total Number of Anomalies Fixed in the LUMINARY 1E (Rev 210)..... 20

LUMINARY 1E PCR/ PCNs IMPLEMENTED

317.2	Rescaling Nouns Containing Range and Range Rate
319	A-Priori Terrain (ΔH on Downlist)
324	PGNCS/ AGS RR Data Transfer
333	Change Recognition of ROD Inputs
334 Rev 1	Change DSKY Descent/ Ascent Nouns
335	Remove Alignment Option from P63
336 Rev 1	Allow Extended Verbs During P20 Maneuvers
338	Change LPD Scaling to 1.0^{0} in All Directions
339	Have P20 F50 72 Display Update
340	LATVAL Polarity Change
341	Landing Radar Reasonability Test
343	Disapproval of PCR 340
347	Mod. to Code Word for PGNCS/ AGS Data Transfer
348	New Target - ΔV Program

LUMINARY 1E PCR/ PCNs IMPLEMENTED

1044*	Re-design of R53-R57
1059*	Have Major Mode Changes Set Up a 1/ ACCS
1066	Display N81 On All Passes in P34/ 74 and P35/ 75
1070*	GSOP Change for FDAI Needle Initialization Fix (L-1D-01)
1079	ALMCADR in the Telemetry
1082.2	Update Fixed Constants for 1971-1972 Ephemeris Year
1088	Inhibit Program Change During Critical 10.56 Seconds After IMU CDU Zero
1091	Priority Display Light on DSKY
1093	Eliminate 481 Day TEPHEM Limitation
1095*	Avoid Incomplete Close-out of Manual Rate Command Mode (L-1D-07)
1097.2	V30, V31 Operator Error Lockout
1100	Delete Setting of NODOFLAG in R47
1107	Backup of Abort Bits Chan 30 Bits 1 and 4
1109	Backup of Off (1) Failures of Auto-Throt, Chan 30 Bit 6
1110	Backup for Failure of Inertial Data Bit Chan 30 Bit 6

LUMINARY 1E PCR/ PCNs IMPLEMENTED

1111	Backup Failure of Auto-pilot Mode & AGS/ PGNS Select Switch Chan 30 Bits 10, 13 & 14
1117.2	Addition to P00D00 Logic
1121	Replace Acceleration Est. with RCS Inhibit Flags on Non-Powered Downlist
1124 *	Flag Resetting in P00D00 Aborts (L-1D-15)
1126 *	Set NOTHROTFLAG for DPS Impulse Burns
1127 *	Change to Downlist for IMU Pulse
1129 *	Update Mass Dependent Calculations in 1/ ACCS
1132	Correction to PCR 1117.2
1133 *	Revision to Descent Mass Limits
1134	Revision of PCR 1111
1137	Correct Constant for Ascent Guidance (L-1D-16)
1141 *	Initialize FLRCS in P12
1143 *	Section 3 Rev 6 GSOP Changes
1145	Section 4 Rev 9 GSOP Changes

LUMINARY 1E PCR/ PCNs IMPLEMENTED

1147 * Clarification of the Implementation of PCR 334 REV 1 "Change Descent/ Ascent Nouns."

1148 * Add FRSTIME Flag Definition to Section 2 GSOP (L-1D-17)

1149 * Section 2 Rev 11 GSOP Changes

1150 * GSOP Section 5 Rev 10 Changes

1151 * Correct Section 2 GSOP Description of DAPBOOLS Bit 14

1180 * Editorial and Technical Changes to Rev. 9 Luminary 1E Section 4 GSOP.

1181 * GSOP Section 5 Changes for Rev. 11.

1182 * GSOP Section 2 Changes for Rev. 12.

1189 * GSOP Section 3 Changes for Rev. 8.

*PCN

ANOMALIES FIXED IN LUMINARY 1E

L-1D-01	"NEEDLER" Initialization Never Takes Place Following DAP Turn-on if IMU Error Counters (CH 12 Bit 6) are Enabled
L-1D-02	Core Set Overflow (31202) Alarm will result from a Bad Return Pulse Torquing
L-1D-04	P25 will not control Spacecraft attitude if range to CSM is greater than 566 N.M.
L-'D-05	Certain verb routines should not be requested if P20 or P22 is running (L-34)
L-1D-06	"DVTOTAL" incremented twice in one SERVICER Cycle
L-1D-07	Manual rate control mode improper termination (PCR 1095)
L-1D-08	Padlaod "LRWH" Shares Erasable memory location with RM of P20 (L-34)
L-1D-10	Major Mode Changes that leave the DAP with Improper Data
L-1D-11	W_B is mis-scaled by a factor of 2
L-1D-12	Selection of V41N72 while an RR reposition or remode is in progress results in incorrect operation of V41N72
L-1D-14	Set Flagword 5 Bit 12 for Impulsive Burns
L-1D-15	Reset RNDVZFLG (P25FLAG) in P00D00 Sequence (PCN 1124)

ANOMALIES FIXED IN LUMINARY 1E

L-1D-16	Fixed Memory Constant VINJNOM is 5509.3 fps instead of 5509.5 fps
L-1D-17	Flashing V37 which terminate P22 when the Range is greater than 400 N.M and the Range-Rate is Positive may not occur
L-1D-18	R21 & R24 do not clear Designate Flag when it finds the LOS outside Mode II limits in P22
L-1D-19	Restarts in P20/25 may erroneously display V50N16 on DSKY
L-1D-20	Erroneous clearing of REINTFLG by BAILOUT Logic
L-1D-21	An RR antenna reposition initiated by R25 just after starting P20 or P22 can cause P20/P22 to loop
L-1D-23	A yaw transient of about 5 degrees at the end or P64 can occur
L-1D-25	Exiting P63, P40 or P42 with a V37 between AVEGON time or auto-ullage initiate may not kill the waitlist call to initiate ullage

LUMINARY 1E PERFORMANCE TESTING

The Initial Conditions listed below apply to all the tests and any special initial conditions will be indicated in the particular test

1) 1σ IMU, Radar, State Vector Errors
2) Normal Astronaut Interface from Apollo 16 Data File
3) Apollo 16 Operation Trajectory
4) Apollo 16 Erasable Load
5) 71/72 Ephemeris
6) 10% T-LOSS
7) LM-11 Vehicle

LEVEL 6 PERFORMANCE TEST DESCRIPTION FOR LUMINARY 1E

6.1.0 ASCENT & RENDEZVOUS

6.1.1 LM Ascent and LM Active Short Rendezvous-Program Sequence: P57(AT-3), P00, V48, V41N72, P12, V82, V64, P00, V48, P20, V80, P34, V83, N52, N59, V48, P42, V82, P35, V67, V83, P41, V82, P35, V93, P41, V82, P00, P47, P00.

6.2.0 ABORT FROM DESCENT

Initial Conditions :

(1) The LM is yawed left 20^0 at PDI -3 mins. The 20^0 yaw is removed at PDI + 3 mins. This maneuver is done in the AUTO mode.
(2) The Auto throttle and ABORT back up discretes are set.
(3) The abort switch is failed ON.
(4) The SLOSH environment model is not simulated.
(5) The environmental FAST IMU is used.
(6) Abort sequence : Switch to ATTHOLD, Full Throttle, ABORT or ABORT STAGE, V22N46EE, Switch to AUTO.
(7) Terrain slope error of -1^0.

6.2.1 Abort at 33K ft. -program sequence: P00, V48, V64, P63, V57, ABORT P70, N76, N77, N85, P00, V64, V82, V83, P20, P32.

6.2.2 Abort at 7K ft. -program sequence: P00, V48, V64, P63, V57, P64, P70. ABORT STAGE, P71, N76, N77, N85, P00, V64, V82, V83, P20, P32.

6.2.3 Abort after Touchdown-program sequence: P00, V48, V64, P63, V57, P64, P66, P71, P00, V64, V82, V83, P20, P32.

6.2.4 Abort after Touchdown-program sequence: Same as 6.2.3 except the SLOSH and detailed IMU models are used.

LEVEL 6 PERFORMANCE TEST DESCRIPTION FOR LUMINARY 1E

6.3.0 LUNAR SURFACE OPERATION AND ALIGNMENTS

6.3.1 Lunar Surface Operations-program sequence: P68, P00, P12, P57(AT-3), V47, V41N20, P06, P57(AT-3), V63, P22, P57(AT-3), V47, V48, V82, P12, P00.

6.3.2 Inflight Alignment-program sequence: P00, V06N20, V41N20, V40N20, P51, V06N20, P52, V06N20, V48, V41N72, P52, LPD CAL, COAS CAL, P00.

6.4.0 LUNAR LANDING

Initial Conditions

(1) The LM is yawed left 20^{0} at PDI -3 mins. The 20^{0} yaw is removed at PDI +3 mins. This manuever is done in the Auto-mode.
(2) The AUTO throttle and ABORT back-up discretes are set.
(3) The abort switch is failed ON and the auto throttle failed OFF.
(4) The SLOSH mode is not simulated.
(5) The environmental FAST IMU is stimulated.
(6) Terrain slope error -1^{0}.

6.4.1 Lunar Landing-Auto (Error Free)-program sequence: P00, V48, V64, P63, V57, N68, N92, P64, P66, P68, P00.

6.4.2 Lunar Landing Auto-program sequence: P00, N69, V48, V64, P63, V57, N69, N69, P64, P66, P68, P00.

6.4.3 Lunar Landing-Nominal program sequence: P00, V48, P63, N69, P64, P66, P68, P00. (Offset Landing Site)

6.4.4 Lunar Landing-Nominal-program sequence: P00, V48, P63, N69, P64, P66, P68, P00. (Corrected Landing Site)

6.4.5 Lunar Landing-N69 Red Line-program sequence: P00, V48, V64, P63, P57, N69 P64, P66, P68, P00.

LEVEL 6 PERFORMANCE TEST DESCRIPTION FOR LUMINARY 1E

6.6.0 RTCC COMPATIBILITY TESTS

6.6.1 Uplink Test

LUMINARY 1E

MISSION PROCEDURAL TESTING

In all of the following, the initial conditions were taken from Apollo 16 (Mission J-2) Operational Trajectory Simulator Data Package. The procedures were taken from the Apollo 16 LM Timeline Book (December 17, 1971), the Lunar Surface Checklist (December 21, 1971) and the LM Data Card Book (December 16, 1971). All verification runs performed with and without T-Loss.

1.0.0 DEORBITS using erasable burn program.

1.0.1 Earth orbit deorbit with full DPS stage from Earth orbit prior to TLI. Program flow: P30-P99

1.0.2 Lunar orbit deorbit with post docking weight APS stage. Program flow: P30-P99

2.0.0 INFLIGHT ALIGNMENTS

2.0.1 P52 fine alignment prior to PDI. This test simulates the IMU alignment at 102:50 and the P63 Ignition Algorithm Test. Included in the IMU alignment is a P52 Opt 3 spiral/cursor alignment without torquing, a P52 Opt 3 Mark X/ Mark Y alignment with torquing and a COAS calibration. Program flow: P52-P63.

LUMINARY 1E MISSION PROCEDURAL TESTING

3.0.0	LUNAR LANDINGS. All of the landing simulations start from PDI - 5 min and terminate post P68. Program flow: P63-P64-P66-P68
3.0.1	Nominal auto landing with no perturbations.
3.0.2	Nominal landing utilizing ROD and/or manual throttle with mode control in both ATT HOLD and AUTO
3.0.3	Auto landing with V21 N69 at PDI+ 2 min and V22N69 at PDI+ 5 min.
3.0.4	Auto landing with ACA redesignations
3.0.5	Auto landing with V68 (terminate lunar terrain model) prior to V57
3.0.6	Landing with V68, V21 and V22 N69, ACA redesignations and ROD and/or manual throttle

LUMINARY 1E MISSION PROCEDURAL TESTING

3.1.0 ABORTS from LUNAR LANDING. All abort simulations start from PDI-5 min and terminate after Rendezvous Radar lock on and P32 calculation of next apsidal crossing. All abort testing done with bit 1 of CHANBKUP set.

3.1.1 Abort from 33,000 ft. Program flow: P63-P70-P20-P32

3.1.2 Abort from 7,000 ft. Abort stage at DPS full depletion. Program flow: P63-P64-P70-P71-P20-P32

3.1.3 Abort stage at 7,000 ft. Program flow: P63-P64-P71-P20-P32

3.1.4 Abort stage from surface. Program flow: P63-P64-P66-P71-P20-P32.

3.2.0 LUNAR SURFACE ACTIVITIES

3.2.1 P57 Testing. This test simulates the alignments that are made prior to LGC powerdown and includes a P57 opt 3 technique 1 alignment and 2 P57 opt 3 technique 2 alignments. (A P57 opt 4 technique 3 alignment is included in the ascent test 4.0.1).
Program flow: P57-P00-P57

3.2.2 P22 Testing. This test simulates the P22 tracking scheduled.
Program Flow: P68-P22-P00

LUMINARY 1E MISSION PROCEDURAL TESTING

4.0.0	ASCENT
4.0.1	Nominal ascent thru insertion. Includes a P57 opt 4 technique 3 normally done prior to ascent. Program flow: P68-P57-P12-P00
4.1.0	DIRECT RENDEZVOUS
4.1.1	Ascent thru rendezvous. Simulation starts prior to ascent and include a P57 opt 4 technique 3 done prior to ascent. Program flow: P68-P57-P12-P00-P20-P34-P42-P35-P41-P35-P41-P00
4.1.2	Post insertion thru rendezvous. Simulation starts insertion+1 min. Program flow: P20-P34-P42-P35-P41-P35-P41-P00
4.2.0	COELLIPTIC SEQUENCE RENDEZVOUS
4.2.1	Abort or abort stage at PDI+7 min. thru rendezvous. It was necessary to start this simulation from an abort case as a nominal bailout pad was not provided. A P52 opt 3 alignment is included in this simulation. Program flow: P63-P71-P00-P52-P20-P32-P41-P33-P30-P41-P33-P42-P34-P41-P35-P41-P35-P41-P00

LUMINARY 1E MISSION PROCEDURAL TESTING

5.0.0	DOCKED DPS BURN. All simulations start in lunar orbit and simulate the TEI burn. Program flow: P30-P40-P00
5.0.1	Full CSM, full LM
5.0.2	Partial CSM (post LOI weight), full LM
5.0.3	Empty CSM, full LM

STATUS OF ERASABLE MEMORY PROGRAMS(EMPs) FOR APOLLO 16

	DESCRIPTION	STATUS
LEP 001	Cause a Software Restart Via V31 (EMP 102)	6
LEP 002	EMP to Backup Failed DSKY Key (EMP 100)	5
LEP 003	EMP for N79 Detent Overwrite (EMP 106)	5
LEP 011	Digital Event Timer Goes DSKY (EMP 110)	3
LEP 101	LGC Operation with the IMU Cage Discrete Failed On	2
LEP 102	LGC Operation with ISS Turn-on Discrete Failure	2
LEP 103	LGC Operation with the IMU Operate Discrete Failed OFF	2
LEP 104	EMP for Inhibiting T4RUPT Coarse Alignment of the IMU (EMP 108)	4
LEP 106	EMP for P20 Operation with IMU off (EMP 104)	3
LEP 108	EMP for Performing Descent with Failed CDU's (EMP 103)	3
LEP 109	EMP for IMU Orientation Determination (P51, P57) with Failed CDU's	2
LEP 110	EMP for IMU Re-alignment (P52, P57) with Failed CDU's	2
LEP 201	EMP for Displaying Raw LRH and H-Dot on the DSKY (EMP 107)	3

STATUS OF ERASABLE MEMORY PROGRAMS (EMPs) FOR APOLLO 16

	DESCRIPTION	STATUS
LEP 301	EMP for Guided RCS Translational Maneuvers (P99) (EMP 99)	5
LEP 302	EMP for P47 with DPS/ GTS (EMP 101)	6

1. Not Started
2. In Work
3. Draft Version Submitted to NASA
4. First Official Submitted to NASA
5. Final Version Submitted to NASA
6. NASA Approved/Flight Qualified

ANOMALIES EXISTING IN LUMINARY 1E
(REVISION 210)

ANOMALY	DESCRIPTION	DISPOSITION
L-1D-22	A hardware or software restart during a RR TURNON sequence may result in an incorrect setting of the mode flag (ANTENFLG)	Program Note
L-1D-24	P70 or P71 selection prior to P12 leaves P12 with at least 3 flags abnormally set	Program Note
L-1E-01	If P22 is selected when range to CSM is > 400 NM and closing, then V37 will not flash when ranges < 400 NM and range rate is positive	Program Note
L-1E-02	Exiting P63, P40, or P42 with a V37 approximately 50 microseconds before ullage on will result in ullage coming on and not being terminated, with Average-G integration not running	Program Note
L-1E-03	A V34E response to the flashing V06N60 display in P66 may result in a 31502 bailout alarm	Program Note
L-1E-04	P22 Lunar Surface Navigation initialized the W-Matrix when the mark counter is zero, instead of checking the RENDFLAG. Hence, W-Matrix is initialized each time P22 is selected.	Program Note

ANOMALIES EXISTING IN LUMINARY 1E
(REVISION 210)

ANOMALY	DESCRIPTION	DISPOSITION
L-1E-05 Rev 1	If an engine fail occurs in P70 or P71, and an ENTER response is made to the FLV97, N63 will be displayed with FLV99, instead of N94, N94 will be restored at TIG after the V99 display is answered.	Program Note
L-1E-06	A V78 (LR Spurious Test Routine) during P63 N62 display prior to AVG-G results in Program Alarm 31201 and clobbers the LM Velocity Vector	Program Note
L-1E-07	An inadvertent PROCEED on the V16N80 display in P20 caused the program to get lost	Program Note
L-1E-08	DAP interrupt could occur in the middle of the ZATTEROR zeroing sequence or STOPRATE	No Further Action
L-1E-09	Unintentional software interlock between V97 and the ascent guidance engine-off control logic and conflict in use of TTOGO cell between CLOCKJOB and the ascent guidance equations	Program Note
L-1E-10	A restart during P32, P33, P34, P35 and P72, P73, P74, P75 when P20 is attempting to re-acquire RR Lock-on can result in abnormal program behavior	Program Note

ANOMALIES EXISTING IN LUMINARY 1E
(REVISION 210)

ANOMALY	DESCRIPTION	DISPOSITION
L-1E-11	Restart during P20 or P22 when verb 37 is flashing because the REFSMMAT flag is clear or the IMU is off results in DSKY lockout.	Program Note
L-1E-12	Restart during R04 will cause subsequent selection of R77 to result in OPERATOR ERROR unless a major mode change (V37) has been performed.	Program Note

LUMINARY 1E

DOCUMENT REVIEW

I. LM Flight Data File

LM Timeline Book, dated 12/ 17/ 71, received 1/ 7/ 72.

LM Data Card Book, dated 12/ 16/ 61, received 1/ 10/ 72.

LM System Activation Checklist, dated 12/ 15/ 71, received 1/ 7/ 72.

LM G&N Dictionary, dated 12/ 1/ 71, received 12/ 22 / 71.

Cue Cards, Basic dated 12/ 3217/ , received 1/ 11/ 72.
Change A dated 1/ 18/ 72, received 1/ 28/ 72.

LM Contingency Checklist, dated 12/ 7/ 71, received 12/ 29/ 71.

LM Lunar Surface Checklist, dated 12/ 21/ 71, received 1/ 10/ 72.

LM Systems Data, dated 12/ 3/ 71, received 12/ 5/ 71.

LM Malfunction Procedure, dated 12/ 2/ 71, received 12/ 16/ 71.

II. Crew Procedures Documents

Rendezvous Procedures. dated 12/ 29/ 71, received 1/ 14/ 72.

Comments to the above listed documents are being transmitted via telecon to NASA/ MSC (CF22, CF34) as they develop and in DGM Memos 1174 and 1176.

CONCLUSION

BASED ON THE RESULTS OF THE APOLLO 16 TESTING
MIT/CSD LABORATORY RECOMMENDS
THE USE OF LUMINARY 1E
(Rev 210) FOR MISSION "J-2"