

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MANNED SPACECRAFT CENTER

MINUTES OF MEETING

LM-5

FLIGHT READINESS REVIEW BOARD

HOUSTON, TEXAS

JUNE 23, 1969

The LM-5 Flight Readiness Review (FRR) Board convened at 8:00 a.m., in Room 966, Building 2, Manned Spacecraft Center, Houston, Texas.

Board Members

Chairman: G. S. Trimble

Vice Chairman: G. M. Low

Members: C. H. Bolender  
K. S. Kleinknecht  
W. H. Gray  
C. C. King  
S. H. Simpkinson  
R. A. Gardiner  
W. N. Hess  
C. A. Berry  
M. L. Raines  
D. K. Slayton  
C. C. Kraft, Jr.  
J. J. Williams  
R. A. Petrone

Secretariat: J. A. York

Mr. Gavin and Dr. Tripp represented Grumman Aircraft Engineering Corporation.

Proceedings:

The meeting was called to order at 8:03 a.m. General C. H. Bolender (MSC) summarized the LM-5 FRR Pre-Board activity. In addition, he outlined the agenda of items to be presented to the MSC FRR Board. It was pointed out that all material included in the handouts would not be presented to the Board, but questions could be answered on any items included in the handouts. General Bolender then introduced Mr. M. Dandridge (GAEC).

1.0 Mr. M. Dandridge (GAEC) presented the following item pertaining to the propulsion Subsystem:

### 1.1 RFA 2.6-3 - LM-4 Propellant Quantity Gage (PQGS) Bias.

The anomaly appeared during launch pad checkout of LM-3 and LM-4. Testing indicated that an electrolytic salt in the referenced sensor causes local conductivity increase. Testing indicates that the anomaly will disappear in flight. Both the LM-3 and the LM-4 flight data agreed with predicted data to within +1.3%. GAEC expects the unit in LM-5 to be within this range of accuracy and recommended that LM-5 fly as is. NASA concurred with GAEC on this position. MSC is currently in the process of reviewing all known failures and problems related to this system.

Board Disposition: The data submitted by GAEC represent the test data currently available. In discussing the PQGS, the FRR Board emphasized the importance of resolving the LM-4 anomaly associated with the second low level warning indication. GAEC is to expedite analysis.

In addition, the following action was assigned. GAEC to determine if a gas bubble in the low level sensor (caused during ullage) tripped the Caution and Warning System on the LM-4 flight.

Assignee: GAEC/R. Botwin

Due: June 17, 1969.

### 2.0 The following items pertaining to the Environmental Control Subsystem were presented:

#### 2.1 Open Problem

Overpressure of the LM-5 Primary Heat Transport Section due to a 12 degree Fahrenheit temperature rise during pad move. Extensive pressure versus delta volume tests were run on components and lines and on the LM-8 ECS system to assess the overpressurization of LM-5 system. As a result of these tests, GAEC will recalibrate the coolant ABS pressure transducer, coolant delta P switch, and coolant delta P transducer. In addition, the 210 accumulator has been replaced.

#### 2.2 One Time Anomaly

The cabin repressurization valve actuated momentarily when cabin pressure passed through 3.9 to 4.0 psia. The demand O<sub>2</sub> regulators were in the "egress" mode and the suit loop pressure was at 4.19 psia. Troubleshooting and subsequent testing have failed to reproduce the anomaly. Reshimming the valve switch to a worst-case tolerance buildup has also been unsuccessful in repeating the anomaly. The anomaly lasted for less than one second and GAEC states that this anomaly in flight would have no mission impact. This anomaly has also occurred on previous vehicles. GAEC will review all the anomalies and present a recommended solution to the CCB on June 20, 1969.

### 2.3 One Time Anomaly

Upper hatch dump valve appeared to crack open at 4.8 psig during cabin leak test. The test was successfully rerun with the valve locked closed. The leak was visually detected at the upper hatch. The vehicle hatch seal and dump valve have been analyzed, and GAEC feels the most probable cause was an incorrect setting of the GSE vent valve with resultant error in GSE gage readout. The procedure will be corrected to add a warning and the valve position verified.

Board Disposition: MSC concurs.

### 2.4 LM-4 Flight Anomaly - High CO<sub>2</sub> Partial Pressure.

There was rapid CO<sub>2</sub> partial pressure increase (to 2.5 mm Hg) early in the LM-4 flight. The most probable causes were contamination or malfunction of either the CO<sub>2</sub> sensor or the LiOH cartridge. The cartridge is being analyzed and this analysis should be completed by June 20, 1969. The returned cartridge was pressure tested and is now being destructive tested. There has not been any history of channeling with the LM LiOH cartridge. GAEC is currently performing a circuit analysis of the CO<sub>2</sub> sensor to determine if the unit could have malfunctioned and then "self healed."

Board Disposition: GAEC is to continue analyzing this anomaly. An explanation for the anomaly is required.

Assignee: GAEC - F. Elliot  
MSC - D. Gillen

Due: 6-20-69

Mr. Dandridge then introduced Mr. V. Mairona (GAEC).

3.0 The following items relating to the Electrical Assemblies Subsystem were presented:

#### 3.1 Open Problem

GASTA 1.50 degrees difference in yaw when switching between PGNS and AGS. This difference was verified by failure analysis. The fault in the amplifier was due to a void in the insulation on a resistive substrate. Thermal cycling is believed to be an adequate screen for this problem. There have been no failures due to voids in the insulation on units which passed thermal cycling. The unit now on LM-5 has been thermal cycled. The failed unit was not thermal cycled.

Board Disposition: MSC concurs. Fly LM-5 as-is.

### 3.2 Open Problem

Loss of time on Apollo Mission Timer S/N 111 and 145. The present LM-5 mission timer S/N 106 was run successfully for 36 hours on the bench and for 36 additional hours in the vehicle. The specification allows only one-second deviation in 36 hours.

Board Disposition: MSC concurs. Fly LM-5 as-is.

### 3.3 One Time Anomaly

Improper reset of mission timer (DR273). S/N 145 clock was pulled from the vehicle and returned to the vendor but the anomaly could not be duplicated. Panel 5 on LM-7 was pulled and three broken wires were found in the clock switch harness. LM-5 and LM-6 were then checked and damaged wires were found and repaired. GAEC concluded that the anomaly was caused by the wiring problem, not the mission timer. GAEC is modifying the method and sequence of installing panel components in an attempt to eliminate wiring damage.

Board Disposition: MSC concurs.

Mr. Maiorano introduced Mr. A. Rossoff (GAEC).

4.0 The following items pertaining to the Guidance, Navigation, and Control Subsystem were presented:

#### 4.1 Closed Problem - GDA/DECA Interface Anomaly

The pitch GDA on LM-5 did not start immediately upon application of drive power. The problem was isolated to a transient current phase lag in the GDA drive power. A phase-correcting network has been developed, qualified, and installed on LM-5 and tests have verified proper operation.

Board Disposition: 1. MSC concurs on hardware corrective action.  
2. MSC and GAEC will review the mission rules with respect to a failed GDA and revise as necessary.

Assignee: O. G. Morris

Due: June 23, 1969

#### 4.2 Closed Problem - Exterior Tracking Light (ETL)

The new improved E type Pulse Forming Network (PFN) being used on LM-5 failed during Group C life tests. This qual failure was traced to one of three capacitor sections which GAEC believes was caused by test equipment overstressing the capacitor.



Board Disposition: GAEC to continue investigation of the E type PFN qual failure of the tracking light.

Assignee: GAEC/R. Steele

Due: July 1, 1969

4.3 One Time Anomaly - DR 244; 2 jet/4 jet Switch

During manned sea level tests, jet firing data indicated that two of the four thrusters enabled dropped out for approximately one second after switchover from 2-jet to 4-jet operation. The switch was cycled both at sea level and at altitude in subsequent testing, but the anomaly could not be reproduced. The switch was replaced with a screened switch and failure analysis on the removed switch showed no abnormality. GAEC has researched IM-5 Bethpage test data and has found no other occurrence of this anomaly. The panel wiring has been checked and the ATCA has been tested, but no explanation for the anomaly has yet been found.

Board Disposition: MSC will establish a task team to review the anomaly and recommend a course of action. The findings are to be reported to G. M. Low.

Assignee: MSC - C. Frazier

Due: June 11, 1969

4.4 IM-4 Flight Anomaly - AGS Versus Verb 83-30 Degrees Difference

Verbal reports from the astronauts indicated a difference of 30 degrees between IM-Z axis and local vertical as computed by PGNS (verb 83) and AGS (DEDA address 304) prior to undocking. After undocking, PGNS and AGS agreed.

Investigation revealed that this is normal operation whenever the Z axis is not in the orbital plane:

1. PGNS measures the angle from Z to local horizontal independent of yaw.
2. AGS measures the angle from Z axis to a vector in the local horizontal plane pointed in the direction of flight.
3. When the axis is in orbital plane, the angles will agree.

Therefore, no comparison should be made of the PGNS and AGS when the vehicle is in a yawed attitude. A procedural change may be required to prevent repetition of the anomaly.

Board Disposition: GAEC to furnish IM-4 anomaly closeout report to MSC (G. M. Low).

Assignee: GAEC

Due: June 13, 1969

4.5 IM-4 Flight Anomaly - Gimbal Drive Actuator (GDA) Failure Indicator

During the descent engine phasing burn, the crew reported a Caution and Warning master alarm and engine gimbal caution light. Pitch trim failure indication was observed on telemetry. The possible cause of the anomaly is a coasting GDA. The IM-5 has the redesigned GDA and the DECA has a longer trim malfunction time delay.

Board Disposition: Problem still open.

4.6 IM-4 Flight Anomaly

Unexpected attitude excursions were observed just prior to and during staging of IM-4. The flight data show that the vehicle control mode transferred but the crew does not remember moving the switch. The anomaly could be explained by miswiring of the switch and an intermittent short.

Board Disposition: GAEC will check the detailed wiring list with the schematic to determine if the switch may have been miswired. The problem is still open and will be tracked until closeout by PT.

5.0 The following items relating to the Instrumentation Subsystem were presented:

5.1 Open Problem

Sudden negative shifts in WQMD's on IM-3 and IM-5. The IM-3 unit had a shift both on ground and during flight. A IM-5 unit that shifted about 15% in August 1968 has been removed from the vehicle and has been replaced with a unit which has the corrosion protection. The removed unit was analyzed and a manufacturing error of removing too much wire insulation, which could cause shorts, was found. GAEC is attempting to develop a technique to X-ray the IM-5 flight units for this possible failure mode. The unit on IM-5 is currently being tested for a calibration shift. (Reference RFA 2.4-1).

Board Disposition: The problem is still open. GAEC will recommend proposed action to MSC.

## 5.2 One Time Anomaly

Commander's bus read one volt higher than LMP bus with crosstie circuit breakers closed (DR 295).

The 502-2 and the 504-4 signal conditioning units were pulled from the vehicle, returned to the vendor for testing, and then returned to the vehicle when the anomaly could not be reproduced. Subsequently, the 502-2 unit was replaced and sent back to the vendor for failure analysis, which GAEC estimates will be completed in three to four weeks.

Board Disposition: GAEC is to expedite the failure analysis of the 502-2 SCEA unit to understand the anomaly and resolve the problem. The results are to be submitted to MSC (S. H. Simpkinson).

Assignee: GAEC/J. Riordan

Due: July 1, 1969

6.0 The following items pertaining to the Communications Subsystem were presented:

### 6.1 Open Problem

Adequacy of LM-5 Steerable Antenna (S/N 112) with regard to solder problems experienced on S/N 115 and S/N 117. After reviewing the solder crack problem, the Board agreed that the antenna installed on LM-5 would be flown as is with an open qualification. The current schedule for the improved electronics assembly for LM-5 backup was presented as follows:

Mission Simulation	June 27-30
Mule Tests	June 20
MSC/CCB Decision	June 20-27
KSC Window	June 24-25; July 10
LM-5A at KSC	June 20-28
Launch	July 16

Board Disposition: The replacement will be acceptance tested.

### 6.2 Open problem

The push-to-talk (PTT) switch on the LMP umbilical operated intermittently during the second LM-5 manned altitude run. Analysis of the PTT switch revealed that side pressure on the switch caused intermittent operation. Three other switches were tested and behaved normally. Further analysis of the failed switch is continuing at the vendor's.

Board Disposition: GAEC will continue failure analysis.

Due Date: Prior to CDDT.

6.3 RFA 2.3-1 - VHF Transceiver Corona Testing.

S/N 111 showed 3 anomalies in corona tests, and the S/N 113 special 24 hour corona test showed several anomalies. GAEC has extensive investigations under way to understand the problem. The AOH procedures have been changed to correct the problem should corona occur during flight. There was no evidence of in-flight corona on this unit during the Apollo 10 mission.

Board Disposition: Results of RCA special tests on VHF transceiver will be provided NASA for review. The VHF transceiver now installed in LM-5 will be flown with a qualification waiver.

6.4 LM-4 Flight Anomaly

VHF "A" not operating before undocking. The crew believes the switches were in the correct configuration but was not absolutely certain. This anomaly is still being investigated.

6.5 LM-4 Flight Anomaly

S-Band Antenna lost lock. The most probable cause is that the antenna was operating in the Slew or Off position rather than in the Auto position. Crew debriefing indicates possibility of antenna switch Auto/Off/Slew being thrown from Slew to Off.

Board Disposition: GAEC closeout report due ASAP.

7.0 The following items pertaining to the Radar Subsystem were presented:

7.1 Open Problem

LM-3 landing radar (LR) data show intermittent lockups during engine burns. The most likely cause of this anomaly is pieces of metalized H-Film being burned off the base heat shield and into the antenna pattern. Ryan analysis of data indicated frequent LR lockups to metalized H-Film during LM-3 DPS-1 burn. Ryan is evaluating effects of various types of paint and unmetalized H-Film on the radar operation.

Board Disposition: Preliminary engineering for both changes will be sent to KSC by June 10, and GAEC will inform MSC by June 10 as to when the mod kit will be available.



## 7.2 Open Problem

During closed loop/RR/T tests, the following performance was exhibited:

HF cycle slip (2400 ft error) IDR 6-1222

Low MdS (sensitivity change) IDR 8-1222

Transponder Mod Index slightly low IDR 2-1222

Tests have indicated that the above anomalies were due to instrumentation problems and transponder marginal performance. The CSM 107 transponder was replaced and interface tests were satisfactorily completed. The HF cycle slip and mod index anomalies were reproduced at RCA with the removed CSM 107 transponder.

Board Disposition: IM-5 radar accepted for flight. GAEC to submit formal closeout.

## 7.3 IM-4 Flight Anomaly

Rendezvous Radar range and range rate excessive. First data readout of the RR data is erroneous and should be disregarded.

Board Disposition: MSC has made a procedural change in the crew checklist and this change has been reviewed with the crew. This item is closed.

Mr. Russoff then introduced Mr. T. Kelly (GAEC).

8.0 The following items relating to the Vehicle Design Integration Subsystem were presented:

### 8.1 Closed Problem

The ascent stage cabin skin had two triangular tears and three punctures. These holes were repaired by bonding on 0.020 Doublers and Hi-Locks with Stato-Seals. Analysis of cabin repair shows a minimum factor of safety of 1.50.

Board Disposition: MSC concurs.

### 8.2 RFA 2.11-1. APS Propellant Line Cracks at Torus Bracket.

Cracks were found in the weld joint during ascent tank qual tests. The test article has a 0.035 inch wall thickness while the IM-5 wall thickness is 0.049 inches. Tests were performed on 0.049 inch lines with induced cracks (notched weld). Analysis of the data indicates the line is capable of ten times the qual level cycle exposures.

Board Disposition: The data obtained from tests and analysis were presented to the FRR. Based on these data, the APS torus bracket installation on IM-5 is considered flightworthy. This RFA is closed.

8.3 IM-4 Flight Anomaly - Cabin pressure dropped at IM jettison.

Cabin depressurization rate indicates the most probable cause was either an unlatched hatch or a reverse delta pressure across the hatch at the pyro firing. Photographs of the hatch area are being studied to determine if the hatch was closed and latched.

Board Disposition: Investigation is to proceed to determine the maximum tunnel pressure at the time of pyrotechnic detonation, and the CM forward hatch will be examined for evidence of the explosive devices firing with the tunnel pressurized. In addition, an analytical attempt will be made to relate this explosive firing to structural failure modes which could be induced in the IM hatch. No testing is planned other than a static load test of the hatch.

8.4 IM-4 Flight Anomaly - 3.5 degree alignment difference while docked indicated by telemetry.

The vehicle can tolerate a misalignment of at least 6 degrees; however, North American has taken an action to determine the maximum misalignment that can be tolerated.

Board Disposition: No further action required of GAEC.

8.5 Open Problem - Landing gear thermal protection (reference 6-6-69 CCB) for fire until pad contact vs. fire until probe contact.

The ground effect due to the descent engine extends higher (12 feet vs. 2 feet) from the lunar surface than originally anticipated. The sink rate could be as low as 0.7 feet per second. For low rates of descent, aerodynamic heating from descent engine exhaust gases could cause a binding on both the primary and secondary landing struts and damage to the foot pads. Design fixes, as directed by the CCB, are being investigated by GAEC for the three problem areas. The recommended solution to the landing struts is additional thermal protection which will not interfere with the strut operation. Thermal shields, mounted by use of Velcro pads, are planned for the foot pads and could be installed on the vehicle by June 14.

Board Disposition: GAEC will propose pad fix by June 10, and primary and secondary strut fix by June 11.

8.6 Open Problem - Landing Probe Switch Actuation (Reference RFA 2.10-1).

The IM-3, IM-4 and IM-5 landing probe switches were inadvertently activated during KSC testing. NASA/KSC believes the IM-3 and IM-4 switches were inadvertently tripped during vehicle testing.

Board Disposition: GAEC will change the final reset procedure to assure that the switches are properly set just prior to launch and will use certified technicians.

8.7 Open Problem - DPS Tank Temperature Control.

The IM-4 DPS tanks were loaded with 70° F propellant. After loading, the IM was purged with N<sub>2</sub> at the rate of 2 lb/min for 5 minutes per hour prior to SLA closeout and continuously after closeout. The average outside air temperature was about 90° F during this period of time. Under these conditions, the IM-4 DPS tanks were at 72 to 73° F at launch. This temperature dropped to 70° F during lunar orbit. However, this drop cannot be guaranteed on future flights.

The fracture mechanics limit on DPS tank is 75° F. Due to the fact that the design July day is 103° F, GAEC recommends the following loading procedure for IM-5:

1. Loading propellant at 65° F (minimum temperature capability of loading equipment).
2. N<sub>2</sub> purge increased to 4 lb/min for 5 minutes per hour prior to SLA closeout and continuous purge after closeout.

These precautions should insure that DPS tank temperature does not exceed the fracture mechanics limit of 75° F

Board Disposition: Concur with GAEC recommendation.

9.0 The following items relating to Exceptions and Constraints were presented by Mr. W. Wright (GAEC).

- 9.1 Primary Glycol Pumps - Both primary pumps are powered by the CDR's 28VDC bus. The secondary glycol is powered by the LMP's 28VDC bus. This configuration provides safe abort capability with loss of either bus. Should the CDR bus go out and then subsequently return, the primary pumps may not be usable due to icing of the sublimator. GAEC recommends no change to IM-5.

Board Disposition: GAEC to determine the time it takes to ice up the sublimator should the primary glycol pumps be shut off.

Assignee: GAEC/F. Elliot

Due: July 1, 1969.

9.2 Selection of Inverter #1 for power descent rather than the planned Inverter #2. Failure of inverter #2 could shut off the descent engine during power descent with no automatic refiring of the engine. Inverter #2 was originally selected for the purpose of balancing the load on the two inverters. GAEC recommends that Inverter #1 be used for LM-5.

Board Disposition: GAEC will reevaluate the recommendation to assure safe abort to orbit.

10.0 Mr. M. L. Raines (MSC) made a reliability and quality assurance assessment statement.

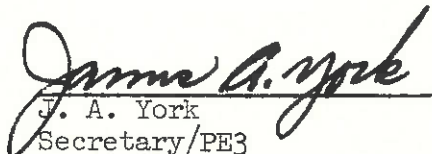
10.1 It was pointed out that LM-5 has no limited life problems. All time/cycle significant items are within specification limits and will not exceed the allowable operation and storage limits through completion of the nominal mission.


10.2 The general quality of LM-5 shows continued improvement with an overall decrease in discrepancies, indicating a general trend toward vehicle manufacturing maturity.

11.0 Reported one-time anomalies were accepted by the Board with the exception of those where followup action was indicated.

12.0 General C. H. Bolender briefly summarized the meeting and pointed out that there are more total open items on LM-5 than on LM-4 at a comparable time. MSC and GAEC personnel were requested to expedite closeout of all open items and problems.

Mr. G. Low adjourned the LM-5 FRR meeting by stating that we need to work "around the clock" to close out anomalies and problems and cautioned GAEC to be more cognizant of schedules regarding closing of all open work.

  
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J. A. York  
Secretary/PE3

  
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G. S. Trimble  
Chairman

JUL 7 1969