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Lunar Module (LM) - Memorandum on LM remedial & Control Procedures for Apollo Operations Handbook

National Aeronautics and Space Administration (NASA)

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MAR 20 1969

CF/W. North C 722

UNITED STATES GOVERNMENT

Memorandum

TO : PA/Manager, Apollo Spacecraft Program

FROM : EA2/Assistant Director for Electronic Systems

SUBJECT: IM RCS A or B System Failures and remedial procedures

DATE: MAR 17 1969

In reply refer to:
EG2-69-12

In response to an action assigned at the February 3, 1969, meeting of the Crew Procedures Control Board, the Guidance and Control Division has developed recommended IM control procedures for failure of an A or B RCS System, reference memorandum EG27-69-71 (enclosed). These procedures cover both the case of failure detection by the caution and warning system and non-detection by the C&W system.

Through discussion with Power and Propulsion Division personnel it was found that the time delays between IM RCS system failures and an indication of failure by the CWEA are not well known. In addition remedial action to restore the system, if possible, is not defined. Although the lack of this data did not prevent development of the control system procedures, the information is desirable from the standpoint of overall vehicle procedures development. In addition it would aid in assessing if there are any particularly points (such as immediately prior to docking) where a failure might become critical.

TO GAEC (RAG)

It is recommended that action be assigned to better define these failure indication delay times and the recommended remedial action to restore a failed system.

Original signed by
ROBERT A. GARDINER

Robert A. Gardiner

Enclosure

cc:
CA/D. Slayton CF/W. North
EA/M. Paget
EA1/A. Bond (w/o enc)
EA5/P. Deans "
EG/Branches (EG23, EG27, EG43) (w/o enc)
EP/J. Thibodaux (w/o enc)
EP4/W. Karakulko "
PA/C. Bolender
PA/G. Abbey (w/o enc)

EG2:DCCheatham:nl 3-11-69



5010-108

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UNITED STATES GOVERNMENT

Memorandum

TO : CA/Director of Flight Crew Operations
Chairman, Crew Procedures Control Board

DATE:

FROM : EA2/Assistant Director for Electronic Systems

In reply refer to:
EG27-69-71

SUBJECT: Recommended LM control procedures for RCS system A or B failure

At the Crew Procedures Control Board Meeting of February 3, 1969, an action was assigned to the Guidance and Control Division to recommend crew procedures in the event of a loss of a LM A or B RCS system. The G&C Division has reviewed the various LM mission phases for evidence of critical control problems caused by RCS system A or B failures. These failures have been evaluated for proper crew procedures, including consideration of any system differences between LM-4 and LM-5. These procedures are enclosed for specific mission phases.

The evaluation disclosed that the time delay between RCS system failure (A or B) and the appropriate caution and warning display is not well defined. By separate correspondence a recommendation will be made to the Manager, Apollo Spacecraft Program Office, that this matter be evaluated to determine if the time delays can be accurately predicted and also if there are remedial actions that could restore the failed system.

The enclosed recommended procedures should be further developed through evaluation on the LM mission simulators.

Robert A. Gardiner

Enclosure

cc:

CB/N. A. Armstrong

CF24/P. C. Kramer

EA/M. A. Faget

EA1/A. C. Bond

EA5/P. M. Deans

EG/R. G. Chilton

EG2/D. C. Cheatham

EG23/T. Lins

W. Peters

EG25/J. T. Edge

EG27/D. W. Gilbert

EP/J. C. Thibodaux

EP4/W. Karakulko

FM7/R. O. Nobles

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EG27:HESmith:amp 3-10-69



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SYMPTOMS AND RECOVERY PROCEDURES FOR
SYSTEM A OR B FAILURES OF THE LM RCS SYSTEMS

It is possible for certain types of propellant valve latching failures to result in loss of the A or B RCS system in the LM with or without activation of the normal caution and warning displays. This paper summarizes the expected symptoms and recommended recovery procedures for the various mission phases. Appropriate signals will be displayed via the RCS TCA warning light and CWEA talkbacks as described in Section 5.2.6 of the LM AOH, Volume I. However, the time delay between failure and the appropriate display is not well defined.

Ia. Mission Phase: Lunar descent to landing

Control Mode: PGNCS AUTO

Symptom: Increased sluggishness in response to LGC commands

Comment: It is possible that a failure may not be detected for some time during the powered descent since RCS activity will be minimal due to the descent engine gimbal capability to control minor attitude corrections. However, the remaining RCS system would be able to control the alternate tasks of either continuing to landing or aborting.

Recommended Procedure:

- a. Prior to C&W display--none. Will probably not be able to detect.
- b. After C&W display--Commander will either continue to land or abort dependent upon time-to-go to landing and mission constraints.

Ib. Mission Phase: Lunar descent to landing

Control Mode: RCAF PGNCS or LM-5 AGS (4 JET LOGIC)

Symptom: Sluggish response to attitude commands. Loss of one system essentially halves the control rotation acceleration.

Comment: This decrease in rotational response has been simulated and determined to be marginally acceptable. It is possible that the failure will not be noticed prior to C&W display and there is no serious problem in this event, as long as the pilot determines that the control task is manageable.

Enclosure

Recommended Procedure:

- a. Prior to C&W display--Commander should either continue to touchdown or abort based on his estimate of control task difficulty to land in the particular environment.
- b. After C&W display--Same as a.

IIa. Mission Phase: Docking, final 25 feet

Control Mode: RCAH, PGNCs & LM-5 AGS (4 JET LOGIC)

Symptom:System A Failed

- (1) No "-Y" translation
- (2) "+Z" also gives left yaw disturbance torque, resulting in some +Y translation.
- (3) "-Z" also gives right yaw disturbance torque, resulting in some +Y translation.

System B Failed

- No "+Y" translation
- "Z" also gives right yaw disturbance torque, resulting in some -Y translation.
- "-Z" also gives left yaw disturbance torque, resulting in some -Y translation.

Comment:

Prior to the final 25-30 feet to docking, the rotation to alignment attitude is made. In 4 jet logic, it is possible that, under light ascent configuration, no notice will be taken of a failed RCS system prior to C&W display. After alignment only translation maneuvers will be made. The above symptoms should provide rapid warning that a failure has occurred. In such a case, the LM closure rate should be nulled with "-X" translation and the CSM should become active to complete docking since complete "Y" and "Z" translation capability does not exist.

Recommended Procedure:

- a. Prior to C&W display--Commander, upon perceiving any of the above symptoms, should null closure rate.
- b. After C&W display--CSM pilot should accomplish the final portion of the docking task.

IIb. Mission Phase: Docking, final 25 feet

Control Mode: RCAH, PGNCS & LM-3/4 AGS (2 JET LOGIC)

Symptom: *

* LM DAP always uses 4 jet logic for RCAH rotation, but X-axis translation and MIN IMPULSE mode can be designated in 2 jet logic. LM-3/4 ATCA has 4 jet logic in yaw control only, but 2 jet/4 jet X-axis translation can be selected.

PGNCS operation and failure symptoms appear similar to that of LM-5. However, AGS control symptoms are as follows:

System A Failed

System B Failed

BAL COUPLE SWITCH OFF

(1) Loss of + pitch control** Loss of-roll control

** "Loss of control" in a specified direction as used herein, means inability to oppose a disturbing torque in that direction.

Comment: If necessary to dock in AGS control, it is recommended that the BALANCE COUPLE Switch be ON. A failure then gives the same symptoms described for 4 jet logic. Attitude control is maintained. However, no precise control of translation can be accomplished. Therefore, it is recommended that the CSM become the active docking vehicle.

Recommended Procedure:

- a. Prior to C&W display--Commander, upon perceiving the above symptom, should place the BALANCE COUPLE Switch to ON and null closure rate.
- b. After C&W display--CSM pilot should accomplish the final portion of the docking task.

III. Mission Phase: RCS translation, rendezvous, and ullage

Control Mode: RCAH, PGNCS & LM-5 AGS (4 JET LOGIC)

Symptom: Same as IIa.

Comment: During rendezvous maneuvers, especially TPI and mid-course, the Y and Z translation symptoms will provide adequate warning. Cooperative maneuvers will have to be made by the CSM at this late stage.

In the earlier maneuvers (CSI, CDH) which are generally X-axis burns, a slight maneuver error will be incurred because of the burn time being doubled.

Four-jet ullage maneuvers will be in error but should not cause insufficient ΔV to be imparted prior to main engine ignition.

Recommended Procedure:

a. Prior to C&W displays--

- (1) X-axis maneuvers--continue maneuver with remaining RCS system.
- (2) "Y" and "Z" axis maneuvers^{*}--LM crew should, upon perceiving the failure symptoms, stop maneuver and notify the CSM. If the maneuver is time-critical (CSI, CPH, TPI, TPF) the CSM pilot should complete the maneuver.

b. After C&W display--

- (1) "X"-axis maneuvers--Same as a(1) above.
- (2) "Y" and "Z"-axis maneuvers--Same as b(1) above.

* If feasible, use X-axis RCS pointed along the resultant thrust vector. However, if IMU, radar lock, or visual constraints prevail, the CSM should accomplish cooperative maneuvers.

IV. Mission Phase: APS maneuver

Control Mode: LM-3/4 AGS

Symptom:

System A Failed

System B Failed

BALANCE COUPLE SWITCH OFF

- (1) Loss of + pitch control Loss of - roll control

Comment:

In general, there will be a loss of pitch and roll attitude control. The magnitude and direction depend on the particular vehicle configuration and/or the time at which the failure occurs during the burn. Control can be regained by placing the BALANCE COUPLE Switch to ON.

Recommended Procedure:UNMANNED VEHICLE MANEUVERS

In order to avoid loss of control in the event of a failure, prior to departure from the vehicle, place the BALANCE COUPLE Switch to ON.

MANNED VEHICLE MANEUVERS

- a. Prior to C&W display--Commander, upon perceiving failure symptoms, should place the BALANCE COUPLE Switch to ON.
- b. After C&W display--Same as a.

PRELIMINARY

SCHEDULED FOR REVIEW & SUBMITTAL OF LM-4 MULTIFUNCTION PROCEDURES

① LAST GAEC REV. DATE
OVERNITE PERIOD OF CLEAN S/C ON
WULFES DATED AS REQ'D

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30		
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RCS																																
APS																																
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APRIL

PLATES DEL TO NASA
ENGRG REVIEW COMRL

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△ CUTOFF DATE FOR CHANGES

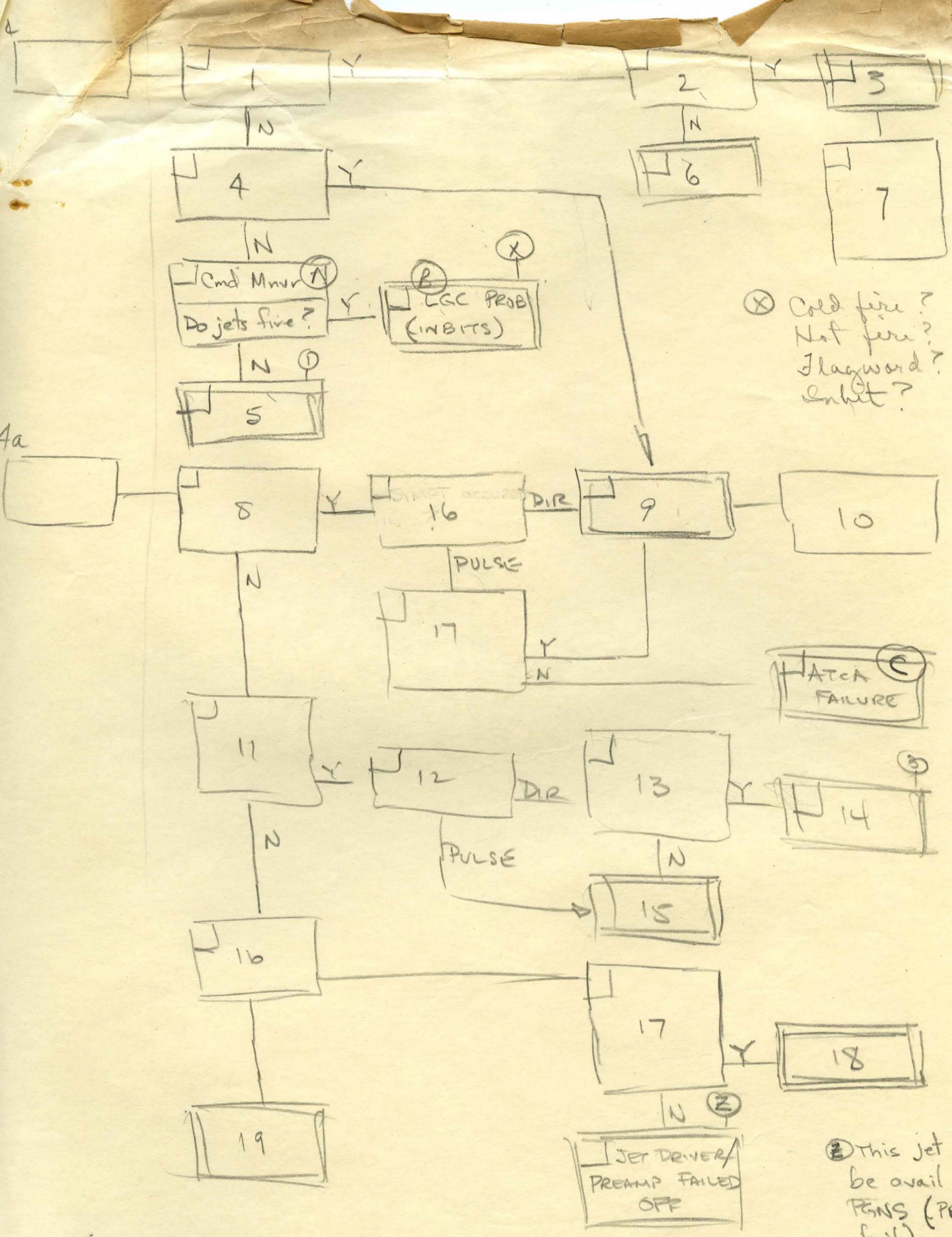
△ CUTOFF DATE FOR RECEIPT OF

△ ENGRG REV OF FINAL

△ DEL TO NASA

△

SYS	date comp	Pages	Pages LM3	Pages LM4 3 Feb	CREW REVIEW CHANGES MADE	PHVM PGS
EPS	12 Mar	6	14	10		
ECS	13 Mar	7	14	13		
ED	13 MAR	1	1	3	25 MAR	1
COMM	14 MAR	3	7	6		
ATRS	3 APR	2	—	3		
LTG	—	0	1	3		
CES	25 MAR	7	21	16		
AGS	28 MAR	1	8	6		
31 PGNS	28 MAR	4	⁸¹ 15	⁶⁸ 8		
34 GFC	29 MAR	3	⁸¹ —	⁷³ 5		
37 DPS	2 APR	3	7	6		
39 APS	3 APR	2	7	5		
41 RCS	3 Apr	2	6	5		
EMU			19	—		
			110	89		



⊗ Cold fire?
 Not fire?
 Flagword?
 Enbit?

HATCA FAILURE ⊕

Ⓜ This jet may be avail in FGNS (Preamp fail.)

4a