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FLIGHT ANOMALY #2 (360-05-10)

3.1.2.1

STATEMENT OF PROBLEM

Post flight playback of DSEA tape indicated low voice level with extremely high audio noise and no Time Correlation Data.

3.1.2.2

DISCUSSION

A. Functional Description

The DSEA is a single speed, four track, magnetic tape recorder which is used to record voice communications originating from the LM. The audio signal is supplied from the astronauts bus in the Communication Subsystem to the DSEA, where it is simultaneously recorded with LM mission time. The DSEA has a 10 hour recording capability but does not have a playback capability built within itself; thus playback must be performed with ground equipment. Along with the voice signal, the DSEA records an internally generated 5.2 KHz reference signal for use during playback. The time correlation data (TCD) is fed directly to the DSEA from the Pulse Code Modulation and Timing Assembly. The TCD voltage varies the frequency of a 4.6 KHz voltage control oscillator in the DSEA and this composite signal consisting of voice, 5.2 KHz reference and TCD modulated 4.6 KHz is recorded on the DSEA tape.

B. Modes of Operation

The DSEA operates in either the manual or semiautomatic mode. In the manual mode the Audio Center switches are in ICS T/R and PTT mode. The PTT position bypasses the automatic voice sense circuits. The Commander or LM Pilot can close a push-to-talk switch on the attitude controller assemblies or the umbilicals and speak into a microphone. The push-to-talk switch energizes the VOX key relay, providing a ground for activation of the power control logic in the DSEA. For operation in the semiautomatic mode the switches are in ICS T/R and VOX (Mode). With the switches set to this position, the VOX trigger circuit is enabled. The Commander or LM Pilot voice will then activate the VOX key relay. Setting the MODE switch to ICS/PTT results in a continuous VOX key for the DSEA. See Figure 1 for detail block diagram.

C. Apollo 11/LM-5 Post Flight Tape Evaluation

Evaluation of the DSEA flight tape by MSC data processing personnel indicated that there was low level voice on the tape along with a high level of audio noise, particularly at 400 cycles. During the EVA portion of the flight the voice clarity increased by a slight amount but was still of such a low level as to preclude complete understanding of all the voice. No time correlation data (TCD) was found during the entire 10 hours of recording. The tape evaluation supported the crew comments at the MSC debriefing meeting that the recorder was operated continuously except during the EVA when it was voice operated (VOX).

The presence on the flight tape of the 4.6 KHz TCD oscillator and the 5.2 KHz reference oscillator signals was verified at MSC indicating that these sections of the DSEA performed normally during the flight. The 4.6 KHz TCD oscillator remained at 4.6 KHz. This oscillator is

normally at 4.2 KHz with a 6 VDC "one level" TCD input and at 4.6 KHz with a 0 VDC "zero level" TCD input or an open input. The fact that the TCD oscillator remained at 4.6 KHz indicates that there was no TCD input to the oscillator during the flight. In general the tape evaluation supports the conclusion that those signals generated internal to the DSEA (4.6 KHz and 5.2 KHz) were recorded normally while those signals generated externally and fed to the DSEA (Voice and TCD) were not recorded normally.

During the evaluation, the first 15 minutes of tape length (15 minutes of KSC check-out and 45 minutes of flight data) was damaged and had to be removed from the flight magazine. This portion of the tape was later spliced into another tape magazine at MSC and was played back. Evaluation of a copy of this portion of the tape at GAC indicated that there was a 1 KHz tone on the tape for about one minute followed by reasonably clear voice which was recorded during KSC CDDT. The amplitude of this information varied considerably. This variation is thought to have been caused by poor tape/head contact due to the postflight tape damage. Since the voice information was clear with none of the background noise present on the remainder of the tape it can be concluded that the voice portion of the recorder was working normally at CDDT.

A spectrum analysis conducted at Grumman on the first 15 minutes of the tape showed that during the CDDT the TCD oscillator remained at 4.6 KHz during the interval when the voice portion of the tape was reasonably clear. This indicates that the TCD pulses were not being fed to the TCD oscillator at this time even though the PCMTEA was operating.

Due to the condition of the first 15 minutes of tape, with the resultant large variations in amplitude it could not be definitely determined at GAC that the TCD oscillator did not change frequency during that period which was supposed to represent the FRT test at KSC. Also, no voice information was found during this period.

D. Possible Causes of Failure

1. DSEA Failure: A review of the DSEA circuitry indicates that there is no single point failure mode within the unit that will produce the flight anomaly conditions. A review of the DSEA failure history indicates that at no time did a failure occur in which a tape recording similar to the LM-5 anomaly was produced.
2. Wire Failure: Faulty wiring will cause a failure of this type. An open TCD ground line (Pin 11) provides no reference signal ground to DSEA. In this condition no TCD will be processed by the recorder and a floating DSEA signal ground will induce high audio noise into the audio amplifier. An open audio input line (Pin 9 or 10) provides a very low voice input to the units audio amplifier. The combination of pin 11 & 9 open or pin 11 & 10 open will provide the same failure conditions as the flight anomaly. A review of the LM-5 cable installation and closeout photographs shows that about ten inches of the cable leading from the DSEA flight connector was accessible in order that the connector could be demated by the

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crew prior to leaving the LM. It is possible this cable could have been damaged during crew activities in the LM cabin. All input lines to the LM-5 DSEA were #26AWG wire except for the two 400 Hz power leads which were #22AWG wire. There were no splices used and no history of rework or repair.

Simulation of failure was accomplished using the LTA-1 DSEA. In the first simulation the DSEA interfaced with DSEA Test Station LSP-410-72010. Voice recording was made with a combination of input lines open and closed. During the playback of the recording it was noted that when pins 11 and 9 or pins 11 and 10 (see figure 1) were open a duplication of the flight anomaly was noted. The voice was at a low level with high audio noise, particularly 400 cycles, and no time correlated data.

A second failure simulation was conducted on the LM-9 vehicle using the LTA-1 DSEA. The recorder was VOX operated while various inputs pins were opened using a breakout box. It was found that whenever pins 9 and 11 or 10 and 11 were opened a duplication of the flight anomaly was produced. During the time that the above pins were opened the vehicle flag appeared to operate normally. The TCD input levels were measured with pins 9, 10 and 11 open and the one level was +1 VDC and the zero level was -5 VDC.

Two additional tests were conducted at BPA to verify the DSEA TCD sensitivity and recorder flag operation. Since a TCD reading of +1 VDC and +4 VDC for the TCD zero and one level respectively had been recorded during FRT at KSC on LM-5 and no TCD was found on the tape, a test was run on the DSEA test station using the LTA-1 DSEA to determine if a DSEA would record normally with a reduced TCD input. The TCD input level to the DSEA was reduced from 0-6VDC in steps down to +1 and +3.9 VDC for the zero and one level respectively. In all cases the recorder worked normally. Lower input levels were not tested because the Test Station did not provide this adjustment range. Since the DSEA was found capable of recording a reduced TCD input, it must be concluded that the +1, +4 VDC reading recorded during FRT on LM-5 was not a valid measurement and may have been caused by an open circuit at the DSEA/vehicle interface.

Since the LM-5 crew reported that the recorder flag appeared to operate normally, a flag sensitivity test was run to verify the recorder flag operation with various DSEA input lines open. The LTA-1 DSEA was operated in the VOX and continuous record modes using the DSEA test station. It was found that whenever pins 9 and 11 or 10 and 11 were open the flag did not operate while recording voice in either VOX or continuous record modes. These results conflicted with both the LM-9 tests and the LM-5 crew report. This difference in operation was probably due to the increased electrical noise on the vehicles as compared to the test station.

E. Apollo 11/LM-5 DSEA Post Flight Failure

MSC informed GAC that a dynamic test was accomplished on the LM-5 DSEA (S/N 125). An hour and half of recording found voice and time correlation data normal during playback. The LM-5 DSEA was shipped to GAC for further investigation. The DSEA was mated to the test station and a functional test performed on the recorder. Playback of the tape indicated that the recorder audio and time correlation data was normal for the first 15 minutes of recording. For the remainder of test no audio output appeared and time correlation data was normal. The failure during GAC post flight checkout of DSEA was not the anomaly experienced during the Apollo 11 mission. A PIRR #J3006 was written on the LM-5 DSEA (S/N 125) and unit shipped to LEACH Corp. for a failure analysis.

Vendor Post Flight Failure Analysis:

LEACH Corp. performed an incoming mechanical inspection and found DSEA S/N 125 mechanically sound. The vendor then performed a functional test and found no audio input being recorded by the DSEA. Investigation of failure found a defective wire wound variable resistor (R36) on the output of the audio amplifier. Parts vendor failure analysis indicates an internal open on the clockwise post of the variable resistor. This failure is in no way related to the flight anomaly. In the case of the flight anomaly there was evidence of low voice level and high audio noise on the tape and in the case of the open variable resistor no voice or audio noise was recorded on the tape. LEACH Corp. replaced the defective resistor and continued on with the following tests:

- a) Acceptance Test Vibration
- b) Acceptance Test Operational
- c) 10 Hours Continuous Recording Test
- d) Temperature Cycle Test (+35°F to 115°F)

In all the above tests audio and time correlated data was recovered to limits required by the acceptance test (LEACH #24-00416). No indication of flight anomaly appeared during LEACH Corp testing of the DSEA. The vendor failure analysis of the variable resistor will be forwarded to GAC at a later date.

F. LM-5 DSEA KSC Checkout

A review of the KSC checkout flow indicates that the LM-5 DSEA was first bench checked during TPS -45 on January 22, 1969 and installed in LM-5 on the same date. The unit was then operated during TCP-0013 (1st altitude run) and was removed from the vehicle, played back normally and reinstalled on March 19, 1969. The second altitude run was completed on March 20, 1969 and the unit was again removed, played back normally, and reinstalled on March 21, 1969.

The DSEA remained in the vehicle and completed TCP-0033 on May 6, 1969. The unit was removed from the vehicle on May 7, 1969

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and played back normally as part of TCP-1222 on the same date. As part of TCP-1222 the tape was erased and a 1 KHz tone was recorded on the tape for about one minute. This 1 KHz signal was later found on the tape during the post flight evaluation and was of reasonably good quality.

During the bench test of TCP-1222 no attempt was made to verify the TCD portion of the recorder and no record was made of the test station time code setting though KSC personnel indicated that the time code was probably set at all zeros. This setting would give a TCD oscillator frequency of 4.650 KHz and would account for the fact that no TCD data was found during post flight evaluation of this portion of the tape.

At the completion of TCP-1222, TPS-358 was written to fit check the recorder in the CSM and after this was completed the recorder was installed in LM-5 for the last time on May 25, 1969.

On June 4, 1969 TCP-0005 (FRT) was completed and the first indication of a possible problem was noted. The DSEA carry-on checkout equipment LSP 410-72060 was used to measure the TCD inputs at the DSEA. Readings of +1 VDC for the TCD zero level and +4 VDC for the TCD one level were recorded. These levels should have been a nominal 0 VDC and 6 VDC for the zero and one level respectively. No discrepancy was noted at this time since the TCP required the levels only to be recorded but no nominal limits were called out. The TCD levels had last been measured during TCP-0033 and were correct at that time.

One other off nominal reading was recorded during TCP-0005 (FRT). The 5.2 KHz reference oscillator output from the DSEA was measured using the LSP410-72060 GSE and was recorded as 3.6 V P-P. The nominal reading should have been $1.8 \pm .5$ V P-P. No discrepancy was noted since no nominal limits were specified in the TCP. This high reading was also noted on LM-7 on Sept 3, 1969 during TPS-84 and was traced to a fault in the LSP 410-72060 GSE. Since this same unit was used to check the LM-5 DSEA, the 3.6 V P-P off nominal reading was probably due to a GSE failure and not due to a DSEA or vehicle problem.

During the FRT the recorder display flag was verified as working normally during voice checks. No recorder checks other than the TCD input, 5.2 KC reference and flag voice operation were tested at this time. Post flight evaluation of the portion of the tape that supposedly represents FRT produced no voice or TCD information but the 5.2 KC reference signal appeared normal.

The last check on the LM-5 DSEA was TCP-0007 (CDDT) run on June 26, 1969. The recorder flag operation during a voice check was the only function verified and was satisfactory. This voice check was found on the flight tape during post flight evaluation and was of reasonable quality.

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CONCLUSION

The most probable cause of this anomaly is considered to be a wiring failure at the input to the DSEA. This conclusion is supported by the following information:

1. A single point failure in the DSEA could not have produced the flight anomaly.
2. The DSEA subsequent to replacement of the failed potentiometer performed normally when subjected to operational, vibration and thermal cycling testing by LEACH Corp.
3. The failure of the potentiometer was in no way related to the flight anomaly and can be presumed to have occurred between Post Flight check-out at MSC and BPA.
4. The post flight tape evaluation and the KSC checkout information both give evidence that there was an off nominal TCD input to the DSEA prior to flight.
5. The flight anomaly was reproduced during post flight testing by a simulated open wiring failure at the DSEA input.

3.1.2.4

CORRECTIVE ACTION

Changes to the Test Specification and Criteria documents for LM-6 & Subsequent vehicle have been reviewed and will include the incorporation of specific values and limits for all applicable DSEA test criteria. These changes will be accomplished through the normal KSC/BPA/MSD change procedures.

Changes to the KSC TCP's providing for a more complete DSEA verification have been discussed with KSC test personnel and will be incorporated through the normal TCP change procedures.

In order to reduce handling of the flight DSEA, GAC recommends that a DSEA from a previous LM flight be provided by NASA to North American Rockwell Corp. for use during CSM/DSEA fit checks.