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TO: [redacted]

FROM: [redacted]

SUBJECT: CR-6 Digital Shift Register - Problem Summary

1. This summarizes problems encountered with the Digital Shift Register (DSR) Command System during Mission 1106. A number of problems are enumerated in some detail here. However, on balance, the flight is considered a successful demonstration of the DSR System.

2. Immediately prior to the flight an extensive commanding exercise was conducted. The exercise involved [redacted] tracking station sending RF commands to a receiver/DSR/TM transmitter breadboard installed in a contractor facility at VAFB; the breadboard "looked" to the tracking station like an in-flight system. The exercise included all of the tracking station/Satellite Test Center communications and T/M verification interfaces.

3. The exercise confirmed confidence in the DSR (though a defective gate was found in one of the DSR's used) and uncovered a number of station and Satellite Control Facility software problems. Many repetitions of the command exercise, STC software modifications and procedure rehearsals occurred in the two weeks preceding the flight.

4. The stations other than [redacted] had had no direct practice with an RF system and some confidence-building and procedure-smoothing went on during the first day. Engineering operations at Rev 1 and 2 [redacted] could not be verified and it was necessary to resort to the Emergency (non-DSR) camera program at Rev 4 [redacted] However, by the end of the first day, all stations had demonstrated their ability to command the system and retrieve and transmit T/M data to the STC.

5. The only serious problem remaining with the Satellite Control Facility was some inadequately debugged software in the Auggie system (Auggie is digital printout of selected T/M data points). This deficiency caused bad data printouts at STC for certain system parameters and contributed to our failure to detect two wrong loads; the Auggie problem was fully corrected for all stations by Rev 38.

6. Specific problems are summarized below:

Rev 4[redacted]

It was impossible to send the DSR load because the station command verification levels were too sensitive; verification circuitry prevented completion of load transmissions. The Emergency backup program specified by SOC for Rev 5 was enabled.

ACTION: Adjusted verification levels and modified some station procedures. No further problems.

Rev 9[redacted]

Correct load sent and verified; however, a malfunction caused an extra word to be placed in the output register and executed prior to the desired first word. (Each of the 32 words in the DSR is sequenced in order thru the output register for execution; as each word is executed, the next word in the sequence is shifted into the output register and begins to search for its ON or OFF punch in the H-timer). On Rev 9 all loaded words were executed in sequence but the extra word made the sequence late and pushed actual camera operations south by approximately 26 degrees. Cause of the malfunction is believed to be a faulty capacitor in a one-shot pulsing circuit.

Following DSR loading and verification, the load execute command is transmitted to the vehicle. This command generates a one-shot pulse which must be long enough to coincide with two DSR timing pulses. The coincident pulses tell a DSR scanning circuit to return to the first word and shift that word into the output register. If the one-shot pulse is not of sufficient length to cover both timing pulses, the scanning circuit will not return to the first word and will shift into the output register either a "200" or any word it happens to be scanning. This anomaly had occurred occasionally in qualification testing - as a result of environment leading to a random tolerance buildup. To preclude such failures, a capacitor was added to the one-shot circuit to increase pulse duration. Failure of this capacitor is a suspected cause for the malfunction on Rev 9.

ACTION: A/P is conducting additional analysis and will make appropriate hardware recommendations. In addition, a special piece of AGE has been requested from Sunnyvale which will permit better checkout of the DSR system for this anomaly.

This malfunction could have been identified and corrected in real time if all Satellite Control Facility auggie software problems had been solved. However, the T/M point which reads the output register was not usable at all stations until Rev 38. This point is now monitored in real time at each loading; if not correct, the load is retransmitted.

Rev 22 [redacted]

Same malfunction as on Rev 9. The Auggie mode necessary for output register verification had just started working properly at this station; however, it was still malfunctioning at so many other stations that it was not yet considered reliable. Result was that actual ops were approximately 40 degrees south of desired location.

ACTION: Same as indicated under Rev 9.

Rev 50 [redacted]

STC Controller was told wrong time for sending load execute command; result was that command was sent too early. Effect was to make DSR sequence approximately 5 degrees early. A "domestic" operation over Alaska (requested by SOC) was south of desired location. However, order of punches actually encountered placed third and fourth words too close, a timing circuit inhibited fourth word at its first execute opportunity, and fourth word was not executed until several cascades later. Fortunately (indeed miraculously!) the later execute punch turned out to be the originally desired location for the fourth word. Therefore, the foreign operation occurred at correct location in spite of wrong command time. Probability of good fortune correcting such a mistake is very close to zero.

ACTION: Command Generator, FTFD, and Resident Office duty officer will cross-check earliest and latest load execute times (which FTFD's provide to STC controllers). AP computer will provide data necessary to enable ROTS duty officer to convert timer tape time to actual clock time (called "system time"--number of seconds from midnight GMT). Duty officer will verify that execute command is sent at correct time.

Rev 57 [redacted]

The DSR was loaded but not verified at [redacted] At backup station [redacted] the load was verified and the execute command was sent. Later T/M data showed that an erroneous word had veen shifted into the output register again. The result was that the desired operates were shifted south approximately 24 degrees.

T/M beacon OFF occurred between the two stations. This function "closes" the shift register but does not shift the first word. In such a case the output register assumes a word "200." This was not a DSR malfunction; it was an operating mode that had not been properly documented.

In this case a major contribution to the error was that the first word in the proper 32 word load was also "200." First word verification of output register could not distinquish the proper "200" from the unwanted one.

ACTION: (1) If execute command cannot be sent at same station that transmitted the load, the load will be retransmitted at second station.

(2) All of the following put "200" into the output register:

- situation described above (Rev 57)
- normal register clearing commands preparatory to loading
- malfunctions of type occurring on Rev 9 and 22

Therefore, all future loads will be generated with words other than "200" as the first word; in that manner positive verification of the output register can be accomplished in real time. This capability is easily exercised in generating manual loads; Lethal software is being modified to permit the same capability for computer generated loads.

Rev 85 [redacted]

It was impossible to verify DSR load because [redacted]/STC computer contact was lost half way thru pass. Acquisition time ran out before voice verification from station printer. Emergency backup program selected by SOC for Rev 85 was enabled.

ACTION: Begin DSR loading as early as possible in pass. In addition, the tracking stations practiced procedures for fast voice readback during post recovery exercises.

7. In summary:

Two loads were wrong due to a DSR shifting malfunction. A hardware fix is expected; however, even if the malfunction should reoccur, telemetry data can be used to identify the malfunction in time for correction.

One load was wrong due to an improper procedure; the procedure has been changed.

One load was wrong because of a human error; however the foreign op was correct because of lucky brush sequencing of fourth word.

Two loads could not be verified; emergency backup loads were enabled.

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