SMEI Flight Model Data Handling Unit

Thermal Vacuum Test Report

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1. Introduction

This document describes the test configuration, verifications performed and results obtained in the thermal vacuum acceptance testing of SMEI Flight Model Data Handling Unit (DHU).

The tests were performed using the thermal vacuum chamber at Birmingham University during the period 2nd – 9th January 2001.

2. Test Configuration

The DHU was mounted horizontally in the thermal vacuum chamber on the thermally-controlled baseplate of the chamber, via a thin aluminium interface plate. The DHU was attached to the interface plate using the spacecraft interface mounting holes.

The DHU was covered completely in a tent of MLI in order to ensure the best possible uniformity of boundary temperatures.

Six channels of external temperature monitoring were provided on the DHU, using thermocouples attached at the following positions:

- DHU PSU Tray, +Y end, close to spacecraft interface attachment point
- DHU End Plate
- DHU Top Plate (centre)
- DHU Sidewall (+X side)
- DHU Sidewall (-X side)
- DHU Connector Plate

Two further channels of external temperature monitoring were provided as follows:

- Interface Plate
- Chamber Baseplate

In addition to these external temperature monitors, the internal DHU temperature monitors were read routinely during the testing. These monitors are located within the DHU at the following locations:

- DHU A Processor PCB, on 1553B bus interface chip
- DHU A Interpoint Power Converter
- DHU B Processor PCB, on 1553B bus interface chip
- DHU B Interpoint Power Converter

The DHU interface connections were routed through an interface plate on the chamber wall to the instrument EGSE, the DHU Dummy Load / Test Box and the Camera Simulator, all installed outside the chamber.

The DHU Dummy Load / Test Box has the following functions:

- To provide dummy loads for the DHU, representative of the loads of the Camera Electronics, HOP Actuators, De-Icer Heaters and Shutter Motor Phases.
- To provide fixed resistors connected across the Camera Temperature Monitor inputs to the DHU.
- To facilitate testing of the Camera Digital Monitor inputs to the DHU in either logic state.

The Camera Simulator is used test the DHU – Camera command and data interfaces. It provides standard test patterns (typically ramp data) to the DHU Camera data inputs in response to *Frame Start* commands sent to the Cameras.

3. Test Profile

Six complete cycles were performed, with a nominal 24hr cycle time, *i.e.* cold-hot and hot-cold transitions were initiated at approximately 12hr intervals.

The temperature specification at the spacecraft mounting face of the DHU was -30°C and +61°C for the cold and hot cases, after the initial cold switch-on. These values provided at least 10°C margin relative to the DHU operating temperature limits of -20°C to +50°C (Coriolis ICD Sect B9.1).

For the initial cold switch-on (Cold Cycle 1) the DHU spacecraft mounting face was at -45°C, providing 15°C margin relative to the DHU minimum switch-on temperature of -30°C and some margin relative to the DHU minimum non-operating temperature of -40°C (ICD Sect B9.1).

The ramp rate used for transitions between temperature limits was set to the maximum achievable with the facility used, *i.e.* ~ 50°C/hr maximum for cold-hot and ~ 30°C/hr maximum for hot-cold transitions.

In summary the test profile performed was:

- Ambient functional test
- Cold switch-on and functional test at -45°C (Cold Cycle 1)
- Hot functional test at +61°C (Hot Cycle 1)
- Five cycles with cold and hot functional tests at -30°C and +61°C, respectively (Cycles 2-6)
- Ambient functional test

Following the initial cold switch-on, the DHU was powered essentially continuously during the testing. This was also useful in accumulating burn-in time for the DHU.

4. DHU Verification Tests

4.1 DHU Switch-On and Boot-Up

DHU switch-on and boot-up was tested by switching the DHU OFF and then ON again by issuing the *RELAY_CMD_POWER_OFF* and *RELAY_CMD_SELECT_A* (or *RELAY_CMD_SELECT_B*) commands from the EGSE.

The following verifications were performed:

- Telemetry functionality was verified by checking correct reception of SOH, Science and Engineering telemetry data on the EGSE. This test was performed using both 1553B bus side A and side B.
- Commanding functionality was verified by issuing the *SM_GOTO_CONF* serial command and checking that the DHU entered Config Mode.
- The typical 28V DHU supply current, as indicated on the EGSE, was recorded for 64 and 128 kbps telemetry data rates.

Expected values for the EGSE supply current (immediately after boot-up, before any Camera loads were switched on) were as follows:

	EGSE Current *
64 kbps Telemetry Data Rate	115 mA ± 10 mA
128 kbps Telemetry Data Rate	130 mA ± 10 mA

Note: * The EGSE 28V supply currents recorded in these tests include an offset of 8 mA which is present when SMEI is switched OFF.

4.2 Analog and Digital Monitor Readings

Typical readings of the DHU and Camera Analog Monitors were recorded. The Camera Digital Monitors were tested using the Dummy Load / Test Box.

Expected values for the DHU Analog Monitor were as follows:

	ADU	**Eng Units**
Instrument Current (note 1)	7 ± 2	0.12 A ± 0.02 A
Processor 5V Supply	130 ± 5	4.98 V ± 0.05 V
Processor PCB Temperature	(note 2)	(note 2)
Power Supply Temperature	(note 3)	(note 3)
Processor PCB Current (note 1)	42 ± 4	0.26 A ± 0.02 A

Notes:
1. Typical value for current after DHU boot-up, value fluctuates with 1553B bus activity.
2. Temperature reading depends on test condition. Processor temperature typically 5-10°C higher than DHU box wall temperatures.
3. Temperature reading depends on test condition. Power Supply temperature typically 3-5°C higher than DHU box wall temperatures.

Expected values for the Camera Analog Monitor readings (in ADU) when the DHU was connected to the Dummy Load / Test Box were as follows:

	Camera 1	**Camera 2**	**Camera 3**
Radiator Temperature	84 ± 2	84 ± 2	84 ± 2
CCD Temperature	84 ± 2	84 ± 2	84 ± 2
E-Box Temperature	129 ± 2	129 ± 2	129 ± 2
Mirror Temperature	129 ± 2	129 ± 2	129 ± 2
Baffle Temperature	84 ± 2	84 ± 2	129 ± 2

4.3 Camera Power Switching

The appropriate commands were send to the DHU to switch 28V power to the dummy loads in the Dummy Load / Test Box which simulate the loads of the Camera Electronics, HOP Actuators, De-Icer Heaters and Shutter Motor Phases. The typical values of EGSE current and the Instrument Current Analog Monitor were recorded.

Expected values were as follows:

	EGSE Current	SMEI (I) Monitor	
		ADU	Amp
HOP Actuators	700 mA ± 35 mA	56 ± 3	0.71 A ± 0.04 A
De-Icer Heaters	600 mA ± 30 mA	47 ± 3	0.60 A ± 0.03 A
Shutter Motor Phases	250 mA ± 12 mA	18 ± 2	0.25 A ± 0.02 A

4.4 Camera Command and Data Interfaces

The DHU was switched to Observing Mode by issuing the *SM_GOTO_OBS* command. The corresponding EGSE current (due to switching 28V power to the dummy loads simulating the Camera Electronics) was recorded. The expected value was as follows:

	EGSE Current
DHU Observing Mode	800 mA ± 40 mA

Typical Cameras 1, 2 and 3 ramp pattern images provided by the Camera Simulator were checked on the EGSE.

4.5 Redundancy Testing

All the above tests were performed using both DHU A and DHU B.

5. Test Results

5.1 Temperature Profiles

Plots of the temperature profiles for the external temperature monitors appear in Part B of this report, Pages 1-6. Temperature data logging was not initiated until a few hours before the cold switch-on, so the plot for Cycle 1 does not show the initial ambient and transition to Cold Case 1.

Using the MIL-STD-1540C (Sect 3.5.7) requirements for temperature stabilisation in thermal vacuum testing (*i.e.* within ± 3°C of temperature specification and < 3°C/hr rate of change for 30 minutes, *at the unit baseplate*) a soak period of at least 4-6 hr was achieved in all cases.

5.2 Verification Test Results

Test result sheets appear in Part B of this report, Pages 7-48.

The results conform to the specified functionality and performance requirements given in Sect 4, except in the following two minor respects:

- There is an offset error of 3-4 ADU in the scaling of DHU B Instrument Current Analog Monitor.
- There is a change of ~ 6% in the Instrument Current Analog Monitor readings between -30°C and +60°C.

Neither of these is regarded as important since the Instrument Current Monitor is only intended to provide an *indication* of the 28V bus current drawn by SMEI, rather than a precise value. The drift with temperature is due to the temperature coefficient of the Hall Effect Sensor used in the current monitor circuit. The test results show that no other analog monitors exhibit any significant temperature drift.

6. Accumulated Burn-In Time

During the testing the FM DHU was operated essentially continuously (without failure) during the period:

Start		**End**		
Date	**Time**	**Date**	**Time**	**Burn-In Time (hr)**
2 Mar 2001	22:00	9 Mar 2001	10:00	116.0
				Total = 116.0

7. Conclusions

The flight model DHU operated correctly throughout the six cycles of thermal vacuum testing, with substantial margins relative to the operating and cold switch-on temperature specifications. There were no significant functional or performance anomalies.

The only minor problems encountered were an offset in the reading of the DHU B Instrument Current Analog Monitor, and a small drift in the Instrument Current Monitors with temperature.