

## **SMEI Flight Model Cameras Vibration Tests**

### **Camera Verification**

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## SMEI FM Cameras Vibration Tests – Camera Verification

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## SMEI FM Cameras Vibration Tests – Camera Verification

### 1. Introduction

This document summarises the results of the verification tests performed on the SMEI Flight Model (and Flight Spare) Cameras immediately prior to, during and immediately after the acceptance level vibration tests.

### 2. Camera Vibration Tests

The vibration tests on the cameras were performed in accordance with the document, "SMEI Flight Model Cameras - Vibration Test Plan", SMEI/UB/PLN/002, Issue 2, 15 Dec 2000.

Acceptance tests were carried out in the Vibration Test Facility at Rutherford Appleton Laboratory (RAL) on the following dates:

Camera 1	4 Jan 2001
Camera 2	4-5 Jan 2001
Camera 3	5 Jan 2001
Flight Spare	19 Dec 2000

Detailed reports on the individual camera tests including accelerometer responses have been provided in the following RAL documents:

AIV-2000-111-VIB	SMEI Camera FM1
AIV-2000-112A-VIB	SMEI Camera FM2
AIV-2000-113-VIB	SMEI Camera FM3
AIV-2000-114-VIB	SMEI Camera FS

The main results of the vibration testing can be summarised as follows:

- The lowest resonant frequency of all cameras was at ~70 Hz with a fairly low Q (~ 5). This is a mode associated with the camera radiator.
- The characteristic signatures from the low-level sine surveys were similar for all cameras.
- There was no *substantial* change in characteristic signatures for each camera as the testing proceeded. Some minor changes, particularly in the response of the accelerometer at the front of the baffle, were due to the door "bedding in" against the door stops. This is normal and has been a feature of all testing done to date.
- There was no visible, audible or other indication of any failure or degradation of any camera at any time during the testing.

### **3. Camera Verification Tests**

#### **3.1 Pre-Vibration**

After each Camera had been installed on the vibrator table but before any vibration had commenced the following tests were performed (using SMEI Camera EGSE) to verify correct operation and integrity of the unit:

- Checked operation of Shutter Motor and Monitors.
- Recorded typical Camera images with 4s exposure with internal and external flat-field LEDs operating.
- Recorded strain gauge readings for Baffle tie-rods.

#### **3.2 Between Vibration Axes**

After each of the first and second axes of vibration were completed the following tests were performed to verify correct operation and integrity of the Camera:

- Checked operation of Shutter Motor and Monitors.
- Recorded typical Camera images with 4s exposure with internal and external flat-field LEDs operating.

#### **3.3 Post-Vibration**

After completion of the final axis of vibration the following tests were performed to verify correct operation and integrity of the Camera:

- Checked operation of Shutter Motor and Monitors.
- Recorded typical Camera images with 4s exposure with internal and external flat-field LEDs operating.
- Performed a Baffle Door unlatching test (with Teflon restraints fitted to limit the Door opening to the minimum required to demonstrate unlatching).
- Recorded strain gauge readings for Baffle tie-rods.

#### **3.4 Subsequent Verification**

Following return of the Cameras to Birmingham University the following additional verifications were performed to verify correct operation and integrity of each unit:

- A full deployment test of the Baffle Door (with the Camera X-axis vertical) in the Class 1000 cleanroom.
- Inspection of the interior of the Baffle under UV light for particulate debris. Any such debris was blown out using a jet of dry N<sub>2</sub> in accordance with the normal cleaning procedures for the SMEI Cameras.
- Separation of the Baffle from the Strong-Box and inspection of the interior of the Strong-Box under UV light for particulate debris. Any such debris was blown out using a jet of dry N<sub>2</sub> in accordance with the normal cleaning procedures for the SMEI Cameras.

**4. Verification Test Results**

**4.1 Camera 1**

Operation of Shutter Motor and Monitors checked:

	Motor Phase 0	Motor Phase 1	Motor Phase 2	Motor Phase 3	Shutter Monitor A	Shutter Monitor B
Before vibration	OK	OK	OK	OK	OK	OK
After 1 <sup>st</sup> axis	OK	OK	OK	OK	OK	OK
After 2 <sup>nd</sup> axis	OK	OK	OK	OK	OK	OK
After vibration	OK	OK	OK	OK	OK	OK

Results from checking typical image file:

	Filename	Image Underscan		External LED (Artificial Star)		
		Mean	Sigma	X-Posn	Y-Posn	Peak
Before vibration	vib_05.img	1041	3.18	638.5	124.0	22335
After 1 <sup>st</sup> axis	vib_15.img	1040	3.09	638.5	124.0	23341
After 2 <sup>nd</sup> axis	vib_45.img	1042	3.02	638.0	124.5	21745
After vibration	vib_50.img	1037	3.00	638.0	124.0	23060

Results for strain gauge readings and corresponding loads (derived from previously measured calibration factors) on Baffle tie-rods:

	Rod #1		Rod #2		Rod #3		Rod #4		Total
	Value	Load (kg)	Value	Load (kg)	Value	Load (kg)	Value	Load (kg)	Load (kg)
	Before Vibration	405	48.6	760	63.3	460	46.0	735	63.5
After Vibration	392	47.0	728	60.7	486	48.6	715	61.7	218.0

Note: Nominal values for individual tie-rods loads are  $60 \pm 20$  kg, and for total load is  $240 \pm 60$  kg

Door unlatching test after vibration: OK

Results of the Door deployment test and inspection of Baffle and S-Box interiors in the Class 1000 cleanroom after return to Birmingham were:

<b>Date</b>	9 Jan 2001
<b>Door Deployment Time</b>	$0.7 \pm 0.1$ sec
<b>Inspection of Baffle Interior</b>	No visible damage and no debris. A few (< 6) dust particles were seen and blown out.
<b>Inspection of Strong-Box Interior</b>	No visible damage and no debris. A few (< 6) dust particles were seen and blown out.

#### 4.2 Camera 2

Operation of Shutter Motor and Monitors checked:

	Motor Phase 0	Motor Phase 1	Motor Phase 2	Motor Phase 3	Shutter Monitor A	Shutter Monitor B
Before vibration	OK	OK	OK	OK	OK	OK
After 1 <sup>st</sup> axis	OK	OK	OK	OK	OK	OK
After 2 <sup>nd</sup> axis	OK	OK	OK	OK	OK	OK
After vibration	OK	OK	OK	OK	OK	OK

Results from checking typical image file:

	Filename	Image Underscan		External LED (Artificial Star)		
		Mean	Sigma	X-Posn	Y-Posn	Peak
Before vibration	vib_10.img	1057	2.94	628.5	129.0	37771
After 1 <sup>st</sup> axis	vib_25.img	1055	2.88	628.5	129.0	37899
After 2 <sup>nd</sup> axis	vib_40.img	1057	3.06	629.0	130.0	36849
After vibration	vib_55.img	1053	3.08	628.5	129.0	37773

Results for strain gauge readings and corresponding loads (derived from previously measured calibration factors) on Baffle tie-rods:

	Rod #1		Rod #2		Rod #3		Rod #4		Total
	Value	Load (kg)	Load (kg)						
Before Vibration	1050	78.8	595	64.9	755	75.5	716	56.2	275.3
After Vibration	1020	76.5	587	64.0	758	75.8	712	55.8	272.2

Note: Nominal values for individual tie-rods loads are  $60 \pm 20$  kg, and for total load is  $240 \pm 60$  kg

Door unlatching test after vibration: OK

Results of the Door deployment test and inspection of Baffle and S-Box interiors in the Class 1000 cleanroom after return to Birmingham were:

<b>Date</b>	9 Jan 2001
<b>Door Deployment Time</b>	$0.7 \pm 0.1$ sec
<b>Inspection of Baffle Interior</b>	No visible damage and no debris. A few (< 6) dust particles were seen and blown out.
<b>Inspection of Strong-Box Interior</b>	No visible damage and no debris. A few (< 6) dust particles were seen and blown out.

### 4.3 Camera 3

Operation of Shutter Motor and Monitors checked:

	Motor Phase 0	Motor Phase 1	Motor Phase 2	Motor Phase 3	Shutter Monitor A	Shutter Monitor B
Before vibration	OK	OK	OK	OK	OK	OK
After 1 <sup>st</sup> axis	OK	OK	OK	OK	OK	OK
After 2 <sup>nd</sup> axis	OK	OK	OK	OK	OK	OK
After vibration	OK	OK	OK	OK	OK	OK

Results from checking typical image file:

	Filename	Image Underscan		External LED (Artificial Star)		
		Mean	Sigma	X-Posn	Y-Posn	Peak
Before vibration	vib_20.img	1079	3.22	628.5	131.0	14467
After 1 <sup>st</sup> axis	vib_30.img	1077	3.10	629.0	130.0	14203
After 2 <sup>nd</sup> axis	vib_35.img	1078	2.90	628.5	130.0	14419
After vibration	vib_60.img	1077	3.10	628.5	130.0	14320

Results for strain gauge readings and corresponding loads (derived from previously measured calibration factors) on Baffle tie-rods:

	Rod #1		Rod #2		Rod #3		Rod #4		Total
	Value	Load (kg)	Load (kg)						
Before Vibration	802	70.8	890	82.4	968	76.4	784	55.3	284.9
After Vibration	725	64.0	949	87.9	897	70.8	678	47.9	270.5

Note: Nominal values for individual tie-rods loads are  $60 \pm 20$  kg, and for total load is  $240 \pm 60$  kg

Door unlatching test after vibration: OK

Results of the Door deployment test and inspection of Baffle and S-Box interiors in the Class 1000 cleanroom after return to Birmingham were:

<b>Date</b>	9 Jan 2001
<b>Door Deployment Time</b>	$0.7 \pm 0.1$ sec
<b>Inspection of Baffle Interior</b>	No visible damage and no debris. A few (< 6) dust particles were seen and blown out.
<b>Inspection of Strong-Box Interior</b>	No visible damage and no debris. A few (< 6) dust particles were seen and blown out.

#### 4.4 Flight Spare Camera

Operation of Shutter Motor and Monitors checked:

	Motor Phase 0	Motor Phase 1	Motor Phase 2	Motor Phase 3	Shutter Monitor A	Shutter Monitor B
Before vibration	OK	OK	OK	OK	OK	OK
After 1 <sup>st</sup> axis	OK	OK	OK	OK	OK	OK
After 2 <sup>nd</sup> axis	OK	OK	OK	OK	OK	OK
After vibration	OK	OK	OK	OK	OK	OK

Results from checking typical image file:

	Filename	Image Underscan		Internal LED (Flat Field) *		
		Mean	Sigma	X-Posn	Y-Posn	Peak
Before vibration	vib_05.img	1055	3.57	N/A	N/A	5905
After 1 <sup>st</sup> axis	vib_10.img	1057	3.43	N/A	N/A	5768
After 2 <sup>nd</sup> axis	vib_15.img	1060	3.53	N/A	N/A	5622
After vibration	vib_41.img	1056	3.35	N/A	N/A	5941

\* External LED (Artificial Star) was not fitted for these tests.

Results for strain gauge readings and corresponding loads (derived from previously measured calibration factors) on Baffle tie-rods:

	Rod #1		Rod #2		Rod #3		Rod #4		Total
	Value	Load (kg)	Load (kg)						
Before Vibration	811	68.5	688	55.0	574	52.2	573	53.3	229.1
After Vibration	850	71.8	678	54.2	632	57.5	618	57.5	241.0

Note: Nominal values for individual tie-rods loads are  $60 \pm 20$  kg, and for total load is  $240 \pm 60$  kg

Door unlatching test after vibration: OK

Results of the Door deployment test and inspection of Baffle and S-Box interiors in the Class 1000 cleanroom after return to Birmingham were:

<b>Date</b>	9 Jan 2001
<b>Door Deployment Time</b>	$0.7 \pm 0.1$ sec
<b>Inspection of Baffle Interior</b>	No visible damage and no debris. A few (< 6) dust particles were seen and blown out.
<b>Inspection of Strong-Box Interior</b>	No visible damage and no debris. A few (< 6) dust particles were seen and blown out.

#### 5. Conclusions

No failure, malfunction or any other anomaly has been observed as a result of the acceptance vibration tests of the Flight and Flight Spare Cameras, either during the tests or subsequently.