

HIRDLS

HIGH RESOLUTION DYNAMICS LIMB SOUNDER

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Subject / Title: PFM In Flight Calibrator (IFC) Mechanical & Vibration Test Procedures

Contents / Description / Summary:

This document defines the procedure to be used for vibration testing the protoflight model In-Flight Calibrator Subsystem & verifying its mechanical properties.

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Purpose (20 characters maximum):

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1. INTRODUCTION

1.1 Scope

This document details the acceptance vibration tests to be carried out on the HIRDLS Protoflight Model In-Flight Calibrator sub-system. In addition, the mass properties are also determined for the IFC. The aim of the test is verify that the IFC has been assembled correctly using the test levels indicated in section 7.0 of this document. The vibration tests will take place at Oxford University's vibration test facility.

1.2 Test Items

The items to be tested separately are the HIRDLS PFM IFC Black Body (IFCBB) and the IFC Electronics Unit (BEU).

2. APPLICABLE DOCUMENTS

The following documents are applicable to this procedure.

AD1	SP-HIR-188	HIRDLS Subsystem Environmental Requirements.
AD2	TP-HIR-008C	HIRDLS Performance Verification Plan.
AD3	TP-OXF-225	Limited Performance Test Procedure.
AD4	SP-HIR-246	IFC-TSS ICD.
AD5	SP-HIR-216	IFC-STH ICD.
AD6	TP-OXF-253	IFC Aliveness test procedure.

3. CONDITIONS

3.1 Environment

The test items are flight model units and must therefore only be handled by members of the HIRDLS Project in accordance with the HIRDLS Product Assurance Plan - Oxford (PA-OXF-152). In addition, all personnel working in the vicinity of the IFC shall wear clean room coats and hats. The IFC shall also be kept covered with suitable bagging material at all times when the shaker is not actually operating and may remained bagged during the test.

3.2 Personnel

Only those persons directly involved in the test shall be allowed in the facility and those present shall be there at the agreement of the Test Director. The number of people allowed in the near vicinity of the test item during any time shall be limited to three.

The personnel shall include;

1. Test Director	C. Hepplewhite.
2. Project Personnel	R Watkins, or J Whitney, or D. Peters.
3. Facility Personnel	N. O'Donnell.
4. Test Observer	One of the project personnel.
5. Product Assurance	C Hepplewhite.

3.3 Test Tolerances

The maximum allowable tolerance for test parameters shall be as follows. The tolerance specifies the allowable range within which the test parameter (input level), or measurement parameter (output) may vary, and instrument accuracy.

- (a) Linear Acceleration : -0% / +10%
- (b) Vibration level :
 - Sinusoidal : 'g' peak $\pm 10\%$
 - Random : power spectral density $\pm 3\text{dB}$
 - overall acceleration (rms) $\pm 10\%$

Cross talk shall not exceed the input
- (c) Frequencies
 - Below 20 Hz $\pm 0.5\text{ Hz}$
 - Above 20 Hz $\pm 2\%$
- (d) Time : -0% / +5%
- (e) Test fixture transmission amplification : $\leq \pm 3\text{dB}$

3.4 Ambient Test Conditions

Unless otherwise specified in this document, all measurements and tests shall be performed within the following ambient conditions :-

Temperature	$21 \pm 5^\circ\text{C}$
Relative humidity	35% to 75%

4. TEST PREPARATIONS

4.1 Test Facility

The test facility shall be prepared in advance of the arrival of the IFC. All horizontal surfaces near the shaker shall be cleared of any tools or equipment, and be wiped clean to remove any particulate debris.

4.2 Test Item Instrumentation

The test item shall use of one control and one monitor accelerometer, with the response axis aligned with the excitation axis. Shown in figure 1.

4.3 Test Fixture

The IFC adapter plate will be used to attach the IUT to the shaker interface plate.

4.4 IUT Hardware flow

The item under test shall be processed as follows:

1. LPT with IFCBB. (ref. AD6)
2. LPT with IFCBB-simulator (ref. AD3)
3. Vibration sequence BEU then IFCBB per table 6.1-1
4. Safe-to-mate.
5. LPT with IFCBB-simulator.
6. LPT with IFCBB (ref. AD3).

5. INSTALLATION PROCEDURE

The IUT shall be bolted directly on the test fixture using the full complement of stainless steel M4 x 12 for the BEU and M3 x 8 for the IFCBB cap head bolts. These shall be torqued to 2.9Nm. Stainless steel washers shall be used under the bolt heads to prevent damage to the IFC mounting feet.

All connector savers and red-tag items shall be removed from the test item.

6. VIBRATION TEST SEQUENCE

The vibration tests shall be conducted in the sequence shown below for each of the IFCBB and BEU in turn, however in the case of the IFCBB the low-level sine survey can be omitted;

Test No.	Description	Axis ()	BEU Test Levels	IFCBB Test Levels
1	Bare fixture survey	A3	T: 7.1-1	T: 7.1-1
2	Bare fixture test run	A3	T: 7.4-2	T: 7.5-1
3	Low Level Sine Survey	A3	T: 7.1-1	n/a
4	Sine Dwell	A3	T: 7.2-1	T: 7.2-1
5	Random Vibration	A3	T: 7.4-2	T: 7.5-1
6	Low Level Sine Survey	A3	T: 7.1-1	n/a
7	Bare fixture test run	A2	T: 7.4-3	T: 7.5-3
8	Low Level Sine Survey	A2	T: 7.1-1	n/a
9	Sine Dwell	A2	T: 7.2-1	T: 7.2-1
10	Random Vibration	A2	T: 7.4-3	T: 7.5-3
11	Low Level Sine Survey	A2	T: 7.1-1	n/a
12	Bare fixture test run	A1	T: 7.4-1	T: 7.5-2
13	Low Level Sine Survey	A1	T: 7.1-1	n/a
14	Sine Dwell	A1	T: 7.2-1	T: 7.2-1
15	Random Vibration	A1	T: 7.4-1	T: 7.5-2
16	Low Level Sine Survey	A1	T: 7.1-1	n/a

Table 6.1 – Vibration Test Sequence

The order of testing of the three axes can be changed to suit the test facility personnel. The sequence for each axis cannot be altered. The definition of the axes can be found in the ICDs ref. AD4, AD5.

7. TEST LEVELS

7.1 Bare Fixture Survey

A survey of the bare fixture shall be conducted before the test item is fixed in position, using the levels defined in table 7.1-1.

Axis	Frequency (Hz)	Acceleration	Sweep Rate (Oct/min)
All	5 - 2000	±0.2g	2

Table 7.1-1 Bare Fixture and Low Level Survey

7.2 Low Level Survey

A low-level survey of the test item shall be conducted before and after a high level test. The purpose of the survey is too look for signs of changing frequencies that may indicate the onset of failure. The test levels are defined in table 7.1-1.

7.3 Sine Dwell

The sine dwell test is designed to apply limit loads to the mounting feet of the test item. It is equivalent to a static limit load test. The level and duration are defined below in table 7.3-1.

Axis	Frequency (Hz)	Acceleration	Duration
All	20	±13g	0.5sec (10 cycles)

Table 7.3-1 Sine Dwell

7.4 BEU Random Vibration

The random vibration test levels and duration for the Electronic Unit are shown in table 7.4-1, 7.4-2 and 7.4-3.

Axis	Frequency (Hz)	PSD (g ² /Hz)	Duration
A1 LRCF	20	0.01	
(Z in IRCF coords)	50 - 100	0.05	
	110 - 130	0.11	
	150 - 250	0.06	1 minute
	280 - 320	0.08	
	500	0.05	
	800	0.03	
	2000	0.01	
Overall		7.88g RMS	

Table 7.4-1 BEU Random Vibration Levels A1 Axis

Axis	Frequency (Hz)	PSD (g ² /Hz)	Duration
A3 LRCF	20	0.01	1 minute
(X in IRCF coords)	50 - 100	0.1	
	200 - 300	1.0	
	350 - 550	0.22	
	800	0.02	
	2000	0.01	
Overall		15.98g RMS	

Table 7.4-2 BEU Random Vibration Levels A3 Axis

Axis	Frequency (Hz)	PSD (g ² /Hz)	Duration
A2 LRCF (Y in IRCF coords)	20	0.01	
	50	0.02	
	70 - 80	0.3	1 minute
	90 - 130	0.09	
	300 - 400	0.03	
	450 - 550	0.1	
	800	0.02	
	2000	0.01	
Overall		7.99g RMS	

Table 7.4-3 BEU Random Vibration Levels A2 Axis

7.5 IFCBB Random Vibration

The random vibration test levels and duration for the Black Body Unit are shown in table 7.5-1, 7.5-2 and 7.5-3. Notice that the IFCBB LRCF is rotated about the IRCF X axis (A1 co-aligned relative to X), so that A2 to Y and A3 to Z are not co-aligned. However, considering the angles involved and the behaviour of the IFCBB the correspondence of the respective axes in the following tables is assumed valid.

Axis	Frequency (Hz)	PSD (g ² /Hz)	Duration
A3 (Z in IRCF coords)	20	0.01	
	50	0.04	
	80 - 95	0.65	
	200 - 600	0.06	1 minute
	2000	0.01	
Overall		8.93g RMS	

Table 7.5-1 IFCBB Random Vibration Levels A3 Axis

Axis	Frequency (Hz)	PSD (g ² /Hz)	Duration
A1 (X in IRCF coords)	20	0.01	
	50 - 65	0.6	1 minute
	100 - 800	0.02	
	2000	0.01	
Overall		7.12g RMS	

Table 7.5-2 IFCBB Random Vibration Levels A1 Axis

Axis	Frequency (Hz)	PSD (g ² /Hz)	Duration
A2 (Y in IRCF coords)	20	0.01	
	45 - 55	0.5	
	80 - 200	0.09	1 minute
	230 - 600	0.03	

	2000	0.01	
Overall		7.80g RMS	

Table 7.5-3 IFCBB Random Vibration Levels A2 Axis

8. FUNCTIONAL TESTING

A limited performance test (ref. AD4) test shall be carried out on the IFC prior to the start of the vibration test and at the end of testing in each axis. This test will be conducted by HIRDLS personnel using EGSE supplied by the HIRDLS project.

9. PASS FAIL CRITERIA

The IFC shall be deemed to have passed the vibration testing if the following conditions are met;

- No changes in excess of 10% of frequency in acceleration responses in the drive axis.
- No evidence of structural failure.
- No significant variation in functional test data.

10. MASS PROPERTIES

The IFCBB , BEU and Harness mass properties shall be determined by measurement as follows:

Mass using top pan balance to ± 2 % accuracy and 1% resolution.
IFCBB and BEU centres of mass using suspension method to 10% linear dimension.