Stanford University

W. W. Hansen Experimental Physics Laboratory
Gravity Probe B Relativity Mission
Stanford, California 94305-4085

Detector Package Assembly (DPA)
Vibration Qualification Test
P0416 Rev. A
ECO 969

Approval:

John H. Goebel Telescope Readout Cryogenic Electronics Responsible Engineer (TRCERE)	Date
Paul D. Ehrensberger Telescope Readout Electronics Integrated Product Team Leader (TREIPTL)	Date
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1. Introduction

The Isolator, Thermal (TI = P/N 25408-201) is a component of the Detector Mount Assembly (DMA) used in the Gravity Probe B Relativity Mission. The TI is photolithographically produced and epoxy bonded to a Titanium Base and Alumina Disk to produce a DMA. It serves the function of thermal isolation in a vacuum between the detector platform, which must operate above 30 K in temperature, and the cryogenic heatsink, which is at 2.5 K. It also serves as a flexible printed circuit to carry signals between the Detector Circuit and the Telescope Readout Electronics (TRE) outside the cryogenic vessel. The size of the DMA is similar to that of a gambling die. Two DMAs assembled into a titanium optomechanical package constitute a Detector Package Assembly (DPA).

This vibrational test procedure is intended to qualify the DMA and its TI for flight operation after launch on a Delta II launch vehicle. The TI test article(s) to be used in the test plan are to be engineering prototypes that may not have full electrical functionality for the purposes of evaluating the test results.

2. Test Summary and Objectives

This test will collect data needed to qualify via similarity the flight DPAs.

3. Test Articles

3.1 Introduction

The test article is to be representative of flight hardware. This article is to be supplied by Stanford University and be tested at ARC in the reliability and quality assurance vibrational test facility. The test article will be subjected to vibrational excitation in accordance with the launch vehicle environments of the Delta II launch vehicle, as well as other excitations deemed appropriate.

Prior to test, the test article will be subjected to appropriate tests, optical, electrical and mechanical that will characterize the test article.

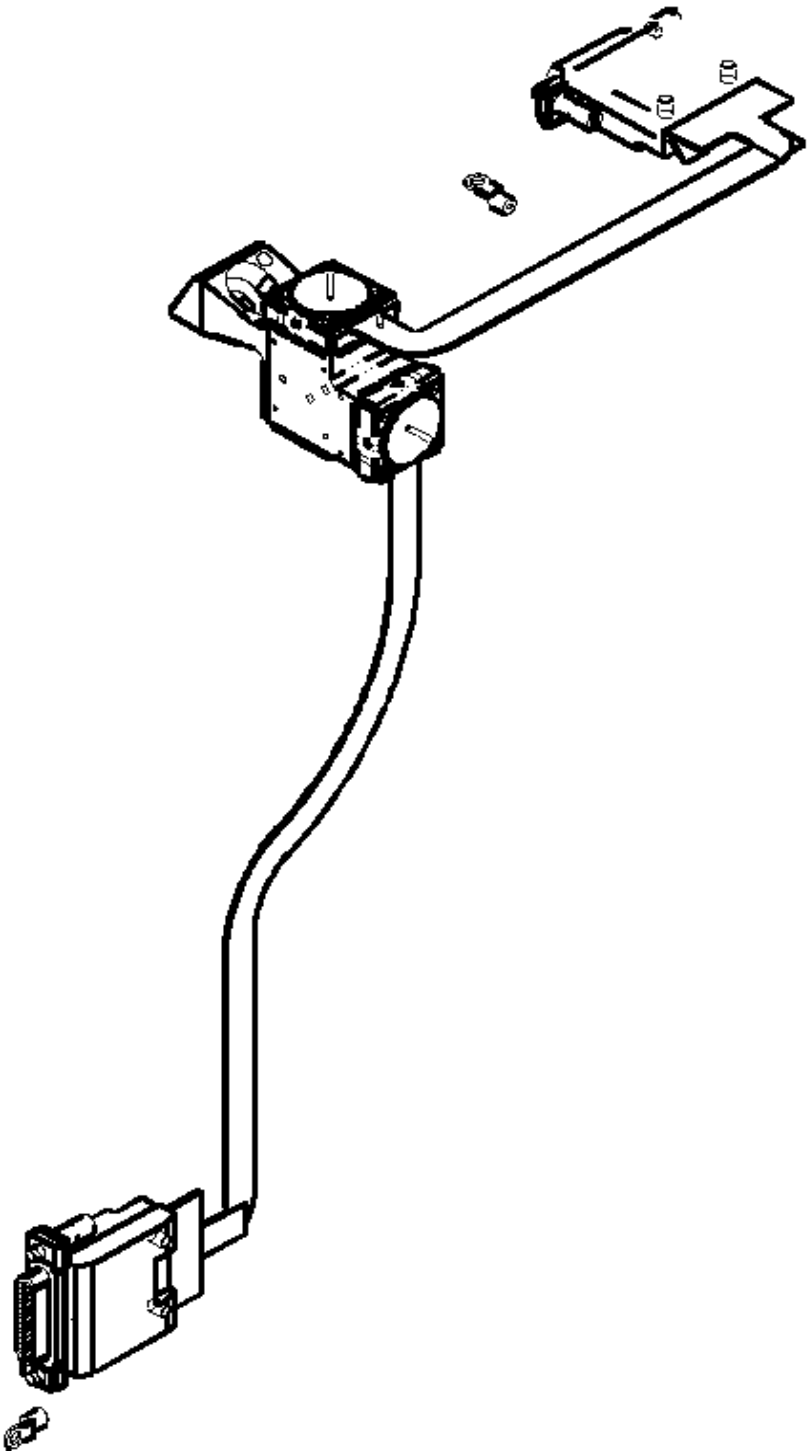
The test articles will consist of a Detector Package Assembly (DPA) mounted in a test dewar that is cooled with liquid nitrogen. A mounting bracket with optical port

will be provided by Stanford that interfaces the test dewar to the shake table. The control drawings for the DPA is 25712.

3.2 Listing of Test Articles

3.2.1 Flight DPA Lot Item

This is a DPA of Flight like quality that is fully funtional electronically and optically. It consists of one DMA only unlike the following figure.



4. Test Equipment

The vibration testing will be performed by the Boeing Test Engineering group in the Code JEE environmental testing laboratory (Building 244 High Bay). The following test equipment can be found there.

4.1 Vibration Exciter, provided by ARC Boeing Test Engineering group in the Code JEE, frequency range 5-2,000 Hz, max 8000 lb for sine and 5,000 lb random force, 1 " max double displacement.

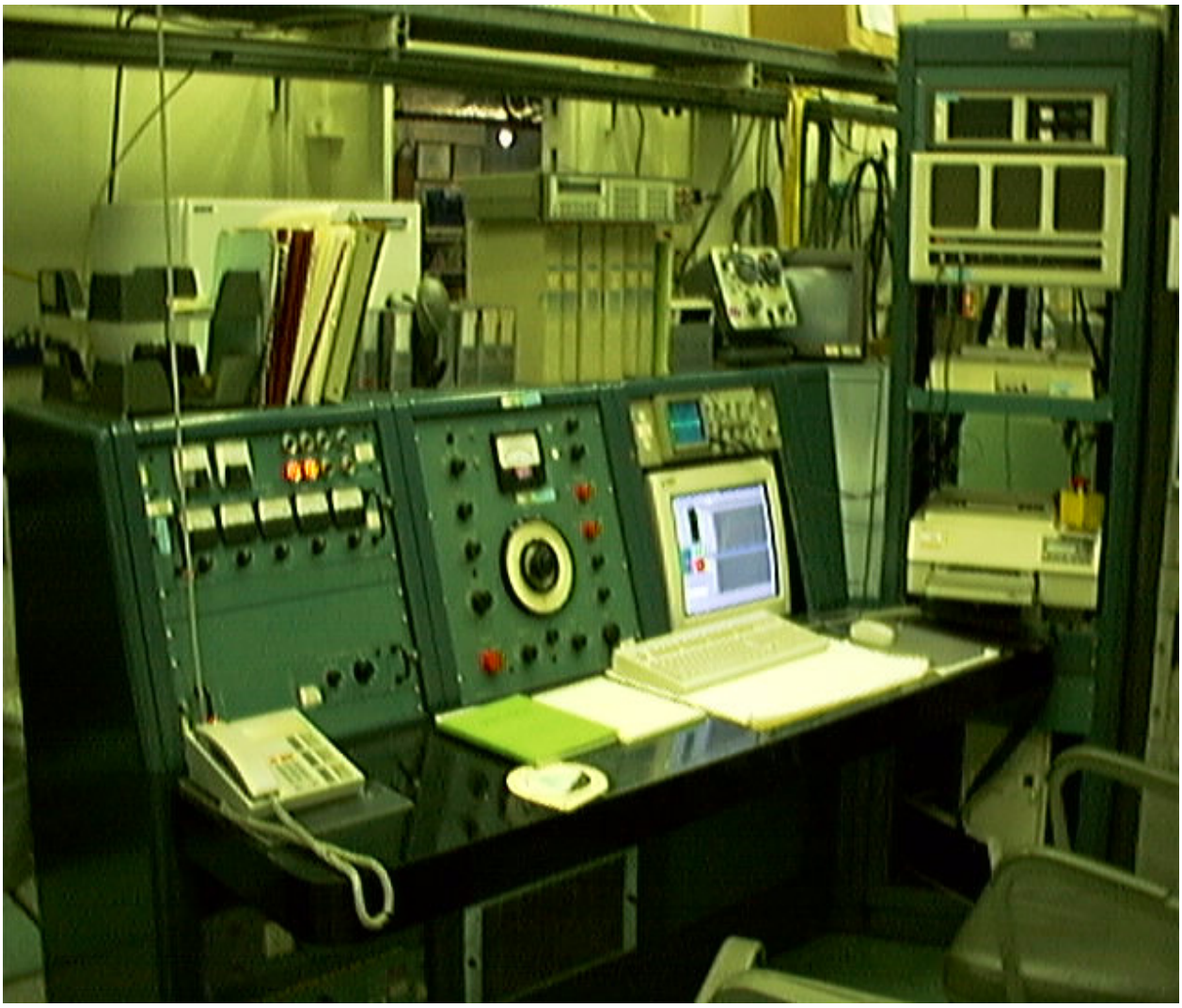
4.2 Horizontal Shaker Table, provided by ARC Boeing Test Engineering group in the Code JEE, is integrated with the Vibration exciter

4.3 Exciter Controller, provided by ARC Boeing Test Engineering group in the Code JEE

Test Equipment Reference Numbers

Item	S/N	DRN	Property Stanford/HEPL LockMar/HP NASA ARC	Calibration Certificate	Last Cal. Date
Ling A300B Vibration Exciter & Shaker Table	115	N/A	NASA 523170	N/A	N/A
General Radio Vibration Control System Model 2511	Various Components	N/A	NASA 755233	N/A	N/A

The Ling A300B Vibration Exciter & Shaker Table with Accelerometers and their amplifiers accompanied by qualified RQ&A personnel Howards Garrison and Menche in Bldg 244 at NASA Ames Research Center, Moffett Field, CA.



The General Radio Vibration Control System Model 2511 for the Vibration Exciter

5. Test Fixtures

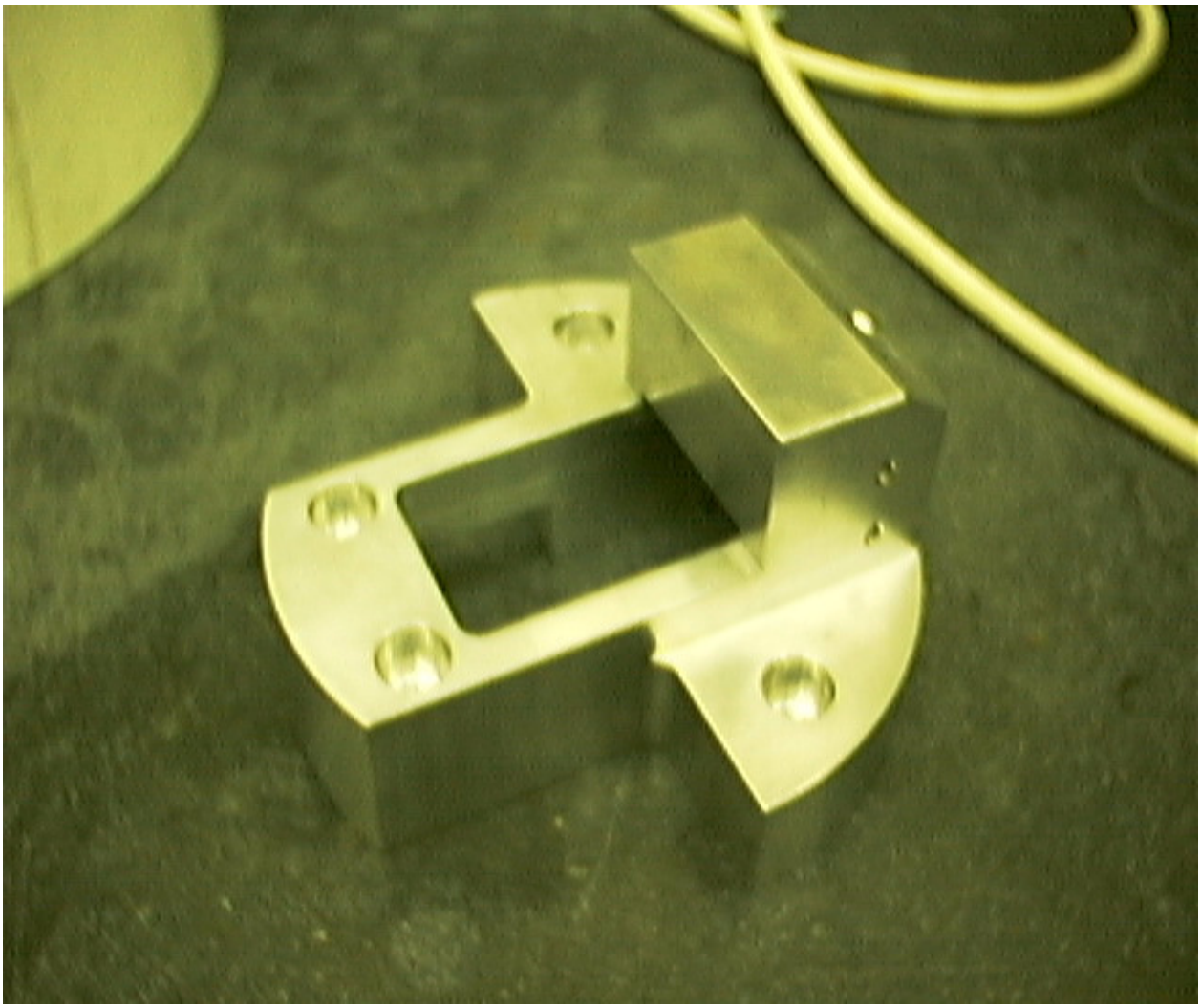
A test fixture will be built to appropriate standards that accomodates the test article and cabling and optical fixtures. A DPA test fixture and flexible cable retainer will retain the test article in a dewar, ARC P/N 526762, which is suitable for Liquid Nitrogen containment and test article constraint during Shake Testing.

Dewar mounted on Shake Table Bracket with 45° deflecting mirror

The DPA test article is to be mounted to the shake table via a mounting plate with test equipment provided by Ames. The resonant frequency of the test article will be determined by scanning the vibrational table at a known frequency and energy. The

amplitude of the test article resonance will be monitored optically, or electrically unless otherwise specified. Electrical measurements will be made with a scanning VOM or other suitable device having at least 12 input channels. Temperature monitoring will be done with a precision voltmeter and current source.

The Test Fixture will consist of a DPA with one DMA mounted in the transmission position. The DPA vibration test mount fixture (P/N 25729-101) will provide for placement in the dewar and electrical feedthough. The cables will be secured to the shake table with tiedowns. The accompanying figures show the dewar and components for Test Fixture A. Note the right angle bracket in the dewar supporting the DMA. The flex cable is wound and screwed down to another bracket mounted to the cold surface. MicroD connectors mate in side the vacuum space and transfer the electrical signals from the flex cable to manganis of low thermal conductivity which terminate on a circular vacuum feed through multipin connector. Serializing traces is accomplished on this connector external to the dewar.



Mounting bracket for Test Fixture A

Electrical cabling and data logging equipment will be secured in an appropriate location to ensure the safety of the operator and conveiniece of operation. The accelerometer will be attached in as near proximity to the dewar as the mechanical configuration will allow.

6. Test Instrumentation

6.1 Listing of Test Instrumentation

6.1.1 Accelerometers, provided by ARC Boeing Test Engineering group in the Code JEE, Sensitivity of 18, and 16.9 pC/g output, frequency range 2-10,000 Hz.

6.1.2 Accelerometer Charge Amplifiers, provided by ARC Boeing Test Engineering group in the Code EEM

6.1.3 Spectrum Analyzer, provided by ARC Boeing Test Engineering group in the Code EEM capable of sine and random power signal analysis.

6.1.4 Computerized Data logger, provided by Stanford, Mac PowerBook 3400c with National Instruments GPIB PCMIA interface card.

6.1.5 Multchannel VOM, provided by Stanford, HP 3457A, calibrated by NASA Metrologic Control Lab, listed in Database

6.1.7 Precision Multchannel VOM, provided by Stanford HP 3458A, calibrated by NASA Metrologic Control Lab, Listed in database

6.1.8 Video Camera, provided by ARC Image Technology Branch formatted for superVHS.

6.1.9 Telescopic Inspection, provided by Stanford

Test Instrumentation Reference Numbers

Item	S/N	DRN	Property Stanford/HEPL LockMar/HP NASA ARC	Calibration Certificate	Last Cal. Date
Endevco Model 2221D Accelerometer	NC39	N/A	33868	NASA ARC	10/10/97
Endevco Model 2221E Accelerometer	PB48	N/A	33868	NASA ARC	10/10/97
PCB Corp Charge Sensitive Amplifier Model 462A	#1 1455	N/A	N/A	NASA ARC C64032	10/6/97

6.2 Software Configuration Control

Copies of the custom software will be filed with the document configuration control librarian of the GPB Project at Stanford University. Currently that person is Mae Sato. All changes made shall be documented and updated copies of the test software deposited with the project librarian, Mae Sato.

Software Inventory and Status

Item #	Version	Name	Date Modified	Status
1	8.1	Mac OS	6/20/97	Stable/Commercial
2	4.1	LabView for Mac	12/31/97	Stable/Commercial
3	7.1.3	GPIB Driver NI-488	2/17/97	Stable/Commercial
4	6.22	DOS	5/31/94	Stable/Commercial
5	3.4	SQUID	12/20/97	Stable/Custom
6	1.0	OpticalResponse = "detector.vi single-ended"	1/13/98	Subject to modification
7	1.0	Noise = "detector.vi differential"	1/14/98	Subject to modification
8	1.0	LeakCurrent = "detector.vi differential"	1/14/98	Subject to modification
9	1.0	TemperatureTest = "detector.vi single-ended"	1/13/98	Subject to modification
10	1.0	Power Dissipation = "detector.vi single-ended"	1/13/98	Subject to modification

Software Inventory and Status Continuation

Item #	Version	Name	Date Modified	Status
12	1.0	Vibration.vi	8/19/98	Subject to modification
13	1.0	Vibsin.sta setup for hp35670A	8/19/98	Subject to modification
14	1.0	hp35670A.vi	8/19/98	Subject to modification
16	3.0.4	KaleidaGraph	6/17/94	Stable/Commercial
17	3.1	Mathcad	1/11/93	Stable/Commercial
18	3.5.4	WordPerfect	5/29.96	Stable/Commercial

6.3 **Listed Equipment**

Listed here are the Database Reference Numbers of equipment to be maintained in calibration for the purposes of testing in this program. The Telescope Readout Electronics Engineering Test Unit (ETU) is not listed because it is Ground Support Equipment which consists of separate components of unlisted equipment. Some of its components need calibration that is handled through internal calibration procedures, e. g., the A/D converter. The ETU oscilloscope is used for monitoring purposes only. The Mac/LabView data acquisition system is not listed as no calibration is possible or relevant. It logs data acquired by the Tek oscilloscopes and the LakeShore temperature controller.

Database Reference Numbers

Item	S/N	DRN	Property Stanford/HEPL LockMar/HP NASA ARC	Calibration Certificate	Last Cal. Date
Tek 744A Oscilloscope	B041929	60	911557 6/ 02119	NASA ARC 365670 M112884	2/09/98
Tek TDS 420A Oscilloscope	B051297	64	911747 1/ HL02263-1	NASA ARC 365669 M112883	2/09/98
Tek TDS 540A Oscilloscope	B011828	65	LM/HP LP 014280 0/ 801229	H1-21 GBTEA	2/25/98
Tek TDS 540A Oscilloscope	B011094	88	LM/HP LP 014397 00/ 800881	NASA ARC 367856 M113260	6/17/98
Silicon Diode Thermometers	BC557T Philips Hamburg Slice #20	62	Stanford University PO U3XD E487740	Inst. Of Cryogenics	7/96
HP 35670A Dynamic Signal Analyzer	3613A02099	89	885934 1/ 01780-1	HP	5/21/96

7. Required Tests

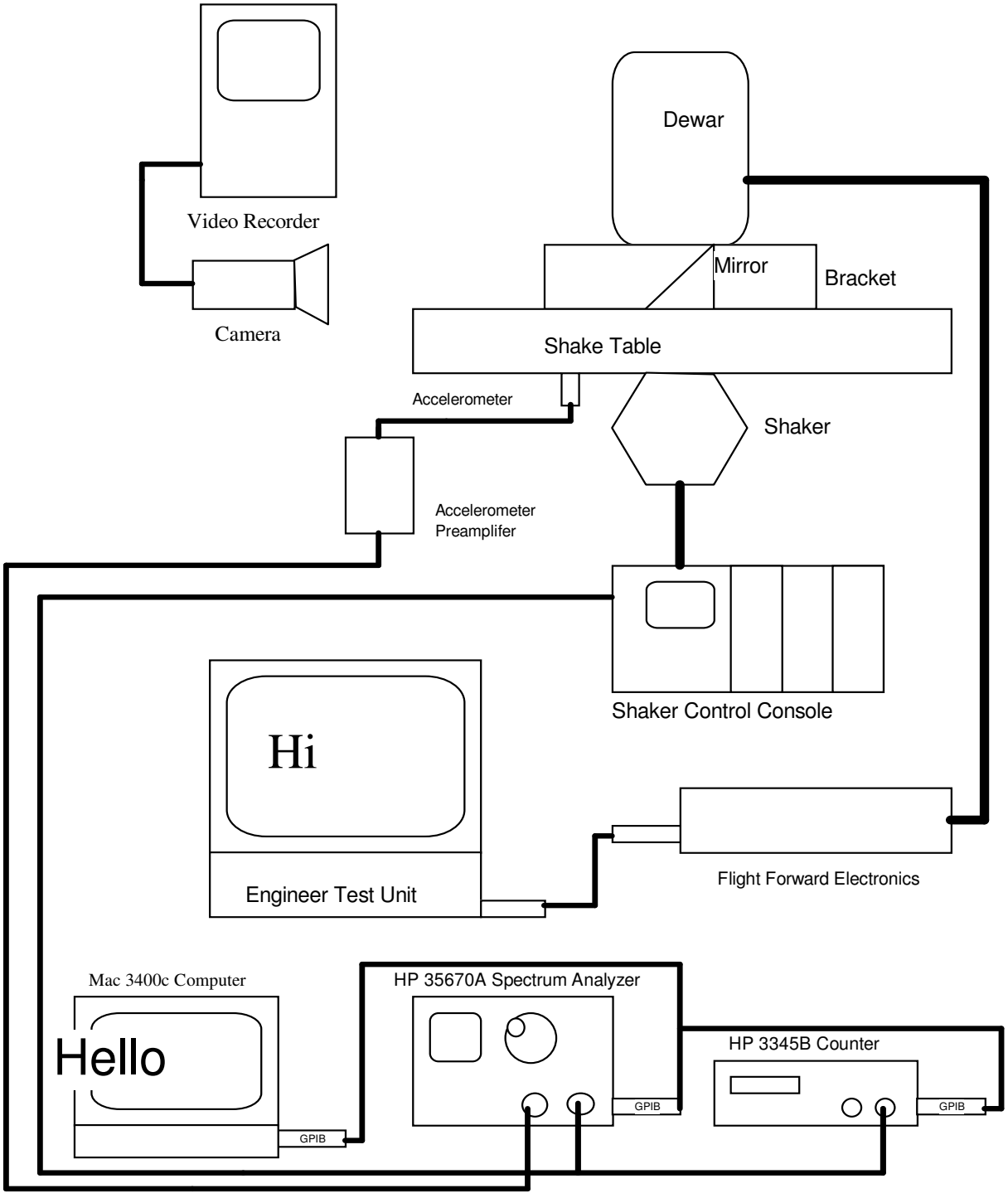
7.0.1 of DPA Flight Lot Item Test Article

7.0.1.1. DPA Vibration Test

Electronic and optical properties to be measured at Stanford per P0392 prior and subsequent to this shake at Ames. Procedures are describe in that document and called out in section 8.3

7.1 Test Setup

Meters, Computer, and Spectrum Analyzers configured for use in the Tests



Schematic Diagram of the Test Setup with Shake Table, Monitor Camera, and Computerized Data logging. Not all are required simultaneously for this test.

7.1.1 Test Electronics Setup

It is assumed that the instruments are powered up and cables are connected in accord with the previous setup diagram.

7.1.1.1 HP 35670A Spectrum Analyzer Setup

1) Insert IBM formatted HD 3.5" diskette with file VIBSIN.STA for setup of HP35670A.

2) Select *local* with HPIB or REMOTE/LOCAL front panel button.

3) Select file VIBSIN.STA and load it.

4) Select *remote* with HPIB or REMOTE/LOCAL front panel button.

7.1.1.2 Macintosh 3400c Setup

1) Confirm GPIB PCMIA card resides lower PCMIA slot and is fully inserted.

2) Connect GPIB adaptor cable with 2 silver connections upright.

3) Boot Computer.

4) Launch LabView.

5) Open vibration.vi, hp3562A.vi, and hp35670A.vi.

6) Launch Kaliedagraph.

7.1.1.3 S-VHS Camera System

1) Setup illumination lamps and camera so as to view the DMA test article.

7.1.1.4 Accelerometer and Preamp

1) Set preamp to gain 5000 and check the accelerometer cabling.

7.1.1.5 Ling Shaker Sin Output.

1) Check connection for 0.5 V p-p output of sine wave from Shaker to Electronic Counter and Spectrum Analyzers.

7.2 **Random Sweep Test Criteria**

The DPA test article is to be subjected to random vibrations on each of the three mutually orthogonal axes for 60 sec/axis. As per DPA requirements, we have the following qualification levels:

Table 7B
DPA Vibration Qualification Criteria

Frequency Range	Level
20	$0.003g^2/Hz$
20-50	+8.3 dB/Octave
50-150	$0.1\ g^2/Hz$
150-1000	-9.8 dB/Octave
> 1000	0.000

Test spectra shall be verified by narrow band spectral measurement using a measurement system independent of the vibrational generator.

Table 7C
Vibrational Test Spectra Verification Requirement

Composite RMS Acceleration	±10%
Sinusoidal Peak Acceleration	+20% -10%
Sinsoidal Control Signal Maximum Harmonic Distortion	±10%
Power Spectral Density	+100% -30%
Frequency	±5%
Test Duration	+10% -0%

7.3 **Test Shake Parameter Specification**

The DMA test article is to be subjected to random vibrations on each of the three mutually orthogonal axes for 60 sec/axis as specified in Table 7B. The subset of tests, the minimal required tests of section 8.4.1, will conform to parameters listed in Table 7B.

8. Measurements

Measurement of the DMA resonant frequencies and their amplitudes as a function of driving frequency and force will be performed with an optical monitoring system provided by the test facility.

Measurement to the position of the optical alignment mark on a test circuit mounted to the DMA will be made before and after the shake test. This will determine any inelastic relaxation of the DMA or other parts of the mechanical structure in the DMA.

Measurement of the detector response, noise, power dissipation, and thermal stablity will be made before and after the shake test. This will determine whether there has been any deleterious effects introduced by the vibrations into the detector and its performance.

8.1 Control Points

For the purpose of controlling vibration, a calibrated accelerometer shall be attached rigidly on the test fixture near one of the fixture/test article interfaces and aligned with the axis of applied vibration (the location with the lowest expected loads levels shall be chosen). The shaker table shall automatically shut off if PSD levels become greater than 6 dB above those specified at any time during the test sequence.

8.2 Vibration Output

Output signals from the test article accelerometer will go to the spectrum analyzer where magnitude of response will be displayed and logged on a computerized data acquisition system..

Output signals from the vibration exciter accelerometer and the test article accelerometer will be recorded simultaneously by the refered to spectrum analyzer and computerized data acquisition system..

X, Y, and Z requirements for both the exciter and test article accelerometer mean that 1 accelerometer output is required.

8.3 Test Procedures

8.3.1 Test 7.0.1.1 DPA Vibration Test

Step	Description	Operator Initials & Date	QA Rep Initials & Date
	Observe all electrostatic precautions, specifically grounding straps and shorting plugs. Refer to P0357.		
	Remove Kapton tape cover from DPA aperture		
	Mount the DPA housing to the Dewar mounting bracket.		
	Check the optical metrological position of the alignment fiducial and record the readings.		
	Note all electrostatic precautions were observed.		
	Mount the DPA and Bracket assembly in the dewar.		
	Mate the MicroD connectors in the dewar.		
	Seal dewar vacuum flanges		

	Transport dewar to pump station and attach, noting vacuum level before opening vacuum valve.		
	Open vacuum valve and Pump out dewar		
	Note final vacuum level		
	Fill the dewar cryogenic space with liquid nitrogen. This can also be done prior to mounting on the optical table.		
	Measure the optical responsivity on the Stanford/Cedar Optical Bench using the Acceptance test setup and procedure.		
	Measure the detector noise on the Stanford/Cedar Optical Bench using the Acceptance test setup and procedure.		
	Measure the power dissipation on the Stanford/Cedar Optical Bench using the Acceptance test setup and procedure.		
	Measure the temperature stability on the Stanford/Cedar Optical Bench using the Acceptance test setup and procedure.		
	Observe all electrostatic precautions, specifically grounding straps and shorting plugs. Refer to P0357.		
	Transport the dewar to ARC for shake testing		
	Mount the dewar on the shake table.		
	Prepare the Video camera for recording. OPTIONAL		
	Start the video camera and make sure that a sound track is being recorded with vocal anouncement of		

	the start of shaking. OPTIONAL		
	Commence random shaking and continue for a duration of 60 sec at qualification amplitude for X axis.		
	Commence random shaking and continue for a duration of 60 sec at qualification amplitude for Y axis.		
	Commence random shaking and continue for a duration of 60 sec at qualification amplitude for Z axis.		
	Stop the shaking.		
	Stop the video recording. OPTIONAL		
	Demount the dewar on the shake table.		
	Transport the dewar to Stanford for optical testing		
	Note all electrostatic precautions were observed.		
	Measure the optical responsivity on the Stanford/Cedar Optical Bench using the Acceptance test setup and procedure.		
	Measure the detector noise on the Stanford/Cedar Optical Bench using the Acceptance test setup and procedure.		
	Measure the power dissipation on the Stanford/Cedar Optical Bench using the Acceptance test setup and procedure.		
	Measure the temperature stability on the Stanford/Cedar Optical Bench using the Acceptance test setup and procedure.		
	Warm up the DMA		
	Bleedup the vacuum pressure		
	Observe all electrostatic		

	precautions, specifically grounding straps and shorting plugs. Refer to P0357.		
	Transport the dewar to the disassembly area.		
	Demate the microD connectors inside the dewar		
	Dismount the DPA and bracket assembly from the dewar as one unit.		
	Note all electrostatic precautions were observed.		
	Check the optical metrological position of the alignment fiducial and record the readings.		

9. **Data Collection**

Digitized data will be collected and a test record kept of measurements and their data files. It is essential that time of data collection and the frequency of the shaker table on the sine sweeps be recorded. A computerized record of the test article performance will be kept by the Engineering Test Unit, if deemed necessary, and the Mac/LabView Data logging system.

Video Camera recordings of the shake test will be made using the S-VHS recording system from the photographic Technology Branch at Ames.

The DPA will have a separately titled notebook that will become the official record of the testing. This procedure will record the history of test article handling. Serial numbers and calibration dates of all measurement equipment used to characterize the test article will be recorded. Test articles will have all relevant identification numbers recorded that will uniquely identify the test article.

9.1 Data Format

Data will be collected and a test record kept of measurements and data files. The files will be written in ASCII format and the file will be in spreadsheet format that is compatible with Kalidagraph 3.0.

Three files folders will be generated for each measurement session. These folders will be stored in a separate folder labeled with the DPA # in the Mac File system.

The frequency and amplitude of the accelerometer will be recorded independently of the Mac/LabView Data logging system using the RQ&A equipment, which is expected to be an HP Spectrum Analyzer like the Stanford HP 35670A.

9.1.1 Data Collected with Flight-like Engineering Electronics Test Unit

These electronics operate the detector platforms in the mode that is expected during the science mission of GPB. They will be refered to as the Engineering Test Unit, Warm Electronics, or Ground Support Equipment Electronics Rack. It will be used at the Stanford/Cedar laboratory.

9.1.1.1 A file for Header

The Header file will record the housekeeping measurements, the measured level of a single ramp, the measured slope of the ramp, and a single measured squared error of a single ramp fit to a linear ramp or each of the detectors if the test includes the TRE and an actitive circuit platform. This is the same ramp that is recorded in the Frame file. Other pertinent measurements like the time of day will be recorded in this file. The time stamp of the Frame file is recorded here. The LakeShore Controller temperature reading from the Si thermometers goes here. The spectral analyzer's frequency and amplitude output from the accelerometer is recorded here. The recordings of the trace resistances from the resistivity measurements go here.

9.1.1.2 A file for Mean.

The Mean file will contain the mean level of the ramp, the mean slope of the ramp, and the mean squared error of the ramp fit to a linear ramp for a series of 100, or other chosen number, readings of the oscilloscope or each of the detectors.

9.1.1.3 A file for Frame

The Frame file will contain the digitized signal of the ramp waveform for each of the detectors for the first ramp in each of the series of 100 ramps that are acquired in the mean file. This is repeated until the stop number 1000, or other chosen number, is attained. The time stamp of the Frame file is entered into the Header file

9.1.1.4 A file for RGA output

The RGA output file has a record of the vacuum system duing the data collection proceedures. It is required for diagnostic purposes.

9.2 Video Taping

The video camera will produce a S-VHS recoding tape that has digitally recorded time and vibration frequency information impressed on each frame.

9.1.2 Data Collected with non-Flight-like Engineering Test Electronics

These electronics operate the detector platforms in the modes that are suitable for laboratory evaluation of engineering parameters.

9.1.2.1 A file for Vibration g-loads during Random shake

The data downloaded from the spectrum analyzer during the random shake will be stored in a spreadsheet format suitable Kalidagraph.

10. Pass-Fail Criteria

Failure consists of :

1) The DMA disassembles. Bond failure between parts ends the test.

2) The alignment fiducial moves from its original postition by an amount in excess of 0.005".

3) Significant changes in the electrical or optical properties, i. e., any of the qualification measurements of optical response, leakage current, or

electronic noise of the DMA following the qualification shakes that change by an amount exceeding 25 % will be considered failures.

11. Test Report

A test report describing test preparation, conduct, data and results will be written and submitted. The recorded data output will be submitted with the final test report.

12. Disposition of materials

Tested parts will be delivered to the integration product team for storage in an appropriate secure clean facility. Rejected parts will be dealt with as required by Quality Plan P0108. Any discrepancies will be reported in the traveler and data report. The recorded data output will be submitted with the final test report.

13. Qualified Personnel

13.1 Test Director

The qualified test director is Paul Ehrensberger, the Integrated Product Team Manager of the Telescope Readout Electronics (TREIPTL).

13.2 Qualified Test Personnel

Other personnel qualified to operate or handle equipment are:

Equipment	Personnel
Macintosh Data System	Ali Kashani, John Goebel
DMA, DPA	Mark Sullivan, Howard Demroff, Scott Fletcher, Nick Scott
Engineering Test Unit	John Goebel, Howard Demroff, Bob Farley, Paul Ehrensberger
Optics and Alignment	Mark Sullivan, John Goebel
Cryogenics	Gene Tam, John Goebel, Paul Ehrensberger,
Vacuum Equipment	John Goebel, Nick Scott, Ali Kashani
Vibrational Equipment	Howard Menche, Walt Garrison

13.3 **Quality Control Personnel**

A quality control witness will be present during testing. The Quality Control Representative, Ben Taller, or his duely appointed representative, TBD, will be present at of the commencement of testing of flight articles, and during the testing of each flight article until the completion of testing.

13.4 **Government Mission Assurance Representative**

The government mission assurance representative testing, Ed Ingraham from Office of Naval Research, will be notified at least 48 hours prior to the commencement of testing of flight articles.

14. **Safety**

Qualified laboratory personnel will conduct these tests. They are required to have undergone laboratory safety training and be up to date. The HeNe laser is class IV, so formal training is not necessary. The optical setup will capture reflected laser beams to avoid injury concerns, either real or imaginary. Experience with handling high pressure gas cylinders and cryogenic fluids is necessary. Safety training for falling objects in case of earthquake is necessary. Safety training in handling of electrical and electronic equipment is necessary. Acoustic energy levels that require hearing protection devices will be monitored.