GRAVITY PROBE B

PROCEDURE FOR

PAYLOAD VERIFICATION

MEASUREMENT OF LEAD SHIELD INTERNAL DC FIELD

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Prepared by: M. Taber, J. Mester

Approvals:

Program Responsibility	Signature	Date
J. Mester Magnetics RE		
D. Murray Test Director		
M. Taber Payload Test Director		
B. Schultz GP-B System Engineering		
B. Taller GP-B Quality Assurance		
S. Buchman GP-B Hardware Manager		

NOTES:
Level of QA required during performance of this procedure:
__X Stanford QA Representative
_____Government QA Representative

All redlines must be approved by QA

Revision Record:

Rev	Rev Date	ECO #	Summary Description

Acronyms and Abbreviations:

Acronym / Abbreviation	Meaning
QC	quick connect
QD	Quantum Design (SQUID system manufacturer)
RCM	Rotating Coil Magnetometer
SMD	Science Mission Dewar

Table of Contents

A Scope

This procedure details the measurement of the ambient magnetic field inside of the SMD flight lead shield with the Lead Bag Retainer installed. The field is measured at the four gyro locations using the Rotating Coil Magnetometer (RCM).

B Requirements Verification

B.1 Requirements Cross Reference: Payload Specification 3.7.5.3.1.2

B.2 Expected Data for verification per requirement: Flux density less than or equal to 1 x 10^{-7} gauss at the science gyro locations. (Note: This is the requirement as of the writing of this procedure. It is anticipated that this requirement will be increased by approximately an order of magnitude.)

C Configuration Requirements

The RCM has been installed in the Well of the SMD and has been positioned with the center of the rotating coil located at the station number that gyro #4 would occupy when the Probe is inserted. This is the condition that should result by completion of TM 65 of P0137A. The 6" Annular Baffle which supports the temporary internal Cryoperm shield must be installed in the Well. Failure to have the Cryoperm shield installed will cause a spurious signal to appear at the level of a few microgauss.

C.1 General requirements:

C.1.1 Clean room gloves shall be worn by all persons working on hardware to be inserted into the well. For any work performed at the level of the dewar opening clean room shoes shall be worn in addition

C.1.2 During operations with the Well the pressure should remain positive to avoid air incursion into the well. Pressure in the Well will be limited by relief valves, but in general, it is desirable to not exceed 5 oz/in^2.

D Hardware Required

D.1 Commercial test equipment

Manufacturer / Descrip.	Model	Serial Number	Calibr. Exp. Date
Quantum Design dc SQUID controller	5000	DC0113	NR
SHE/BTi current source	CCS	220232-02	9/11/99
Soltec strip chart recorder	DS6404	24116	NR

D.2 Mechanical/Electrical Special test equipment

Description	Part No.	Rev. no.	Serial No.	Certification Date
RCM (with support and adapter hardware to interface with the SMD)	-	-	-	-
RCM control rack (PC, motor controller, printer) to control coil motion, acquire and print data	-	-	-	-

D.3 Tools

Description	No. Req'd
Tape measure	1

D.4 Expendables: None

E Software Required

E.1 Test Support Software

Test Software Name	Version No.
Basic program to operate motor controller and acquire data from the SQUID controller	See para. L.4.2 of procedure

F Procedures Required: None

G Equipment Pretest Requirements: None required

H Personnel Requirements

This test can be conducted by any two of the following individuals: J. Mester , M. Taber, D. Murray. However, J. Mester is required to be present during the first performance of sections L.2- L.6.

I Safety Requirements

I.1 Emergencies: In case of medical emergency or fire, **CALL 9-911**

I.2 Refer to FIST Emergency Procedures SU/GPB P0141 for other types of emergency situations which may occur in the FIST Lab. A copy of this document can be found in the SMD Operations binder. Refer also to the GP-B (FIST) Safety Plan, LMSC F-314447 and the GP-B (FIST) Preliminary Hazards Analysis, LMSC F- 314446 for details concerning hazards and safe operation of Lockheed-supplied equipment.

I.3 Crane operations: The FIST Crane may be operated only by a certified operator who shall verify that the crane has been inspected for proper operation within the previous seven days. Particular care should be taken to make sure that there is freedom of movement before the RCM is moved in the vertical direction with the crane. Failure to check for freedom of motion may result in damage to the RCM with possible contamination of the SMD Well.

J General Instructions

J.1 Redlines can be initiated by J. Mester, M. Taber, or D. Murray and must be reviewed and approved by QA.

J.2 Any nonconformance or test anomaly should be reported by a Discrepancy Report. Refer to the Quality Plan, P0108, for guidance. Do not alter or break test configuration if a test failure occurs; notify quality assurance.

J.3 Only the following persons have the authority to exit/terminate this test or perform a retest: J. Mester, M. Taber, D. Murray.

K References and Applicable Documents: None

L **Operations**

Date: ___________
Time: ___________

L.1 Verifying liquid helium levels:

L.1.1 If required in order to maintain adequate liquid helium level in the well (above STA 200) throughout the measurement sequence, perform internal tank to well transfer per Procedure P210.

Op No.__________

L.1.2 Record helium levels.

Tank ________________ %

Well ________________ %

Axial Lock _______________ %

L.2 Magnetometer setup:

L.2.1 Verify that the vertical position of the magnetometer is at gyro 4 location (pickup coil at STA 143.6; see Fig. 1).

L.2.2 Orient the sensing axis (marked on the brass drive shaft housing at the top of the magnetometer) in the +X* direction (direction opposite Axial Lock #3).

L.2.3 Connect the internal helmholtz calibration coil (9-pin D subminiature connector with filter unit on the RCM) to the 9-pin connector at the back of the breakout box on the RCM instrument rack. (Note: pins 1, 6 are the only active pins.)

L.2.4 Connect the motor drive cables and the Quantum Design (QD) SQUID cable. (The connector at the RCM end of the QD cable contains the preamplifier for the SQUID.) The SQUID cable should be connected to the right-hand SQUID plug-in module at the back of the controller box next to the module with the connectors labeled "analog out", and "level sensor".

L.2.5 Verify that the turns counting dial on the drive shaft housing reads ~005. Note: Turns counting dial advances 100 counts per revolution; it will read ~ 113 after one revolution, the extra counts accounting for backlash.

L.2.6 Turn on power to SQUID controller, motor controller, computer, and printer.

L.3 SQUID set up and health check:

L.3.1 SQUID controller shows the status display for channel 1 on power-up. Push the **Setup: tune** button to access the tune function for channel 1.

L.3.2 For the first time that the SQUID is tuned up after a cooldown, the heater cycle should be used. Push the **+/-** button to specify a heat cycle as part of the tune sequence, then push either the **tune** or **enter** buttons to initiate the tune process. Verify that the display indicates a good tune. After tuning, the display will again show the status display for channel 1.

L.3.3 Press the **setup: config** button to access the configuration menu. Using the arrow buttons, move the arrow cursor to item 3, "Individual channel configuration", then press **enter** to configure channel 1**.** Again use the cursor arrow to go to the "select" option and by pressing the **incr** or **decr** buttons select "1 K" (1 kHz low pass filter).

L.3.4 While still viewing the channel 1 configuration menu, move the arrow cursor to the "range" option. Use the **incr** or **decr** buttons to select "500". Note: The range roughly specifies the number of flux quanta full scale. The options are nominally ±5, ±50, ±500 ϕ_0 full scale (The 5s option is also 5 ϕ_0 full scale, but with a slow feedback to reduce the tendency to flux jump In response to impulsive noise.) In actuality, the number of full scale flux quanta is approximately 70% of these numbers. Since the maximum output voltage is ±5 V, these ranges represent ~0.7, 7, 70 ϕ_0/V.

L.3.5 Verify calibration of the CCS current source: calibration date:__________; calibration due date:____________ QA:__________

L.3.6 Connect the constant current supply to jacks 1 and 6 of the breakout box.

L.3.7 Set the current pot to zero, select the 1 mA range, and turn on the constant current supply. A current of 1 mA should produce a change of ~0.36 V at the SQUID output, assuming the 500 range. The output voltage is displayed at the top of the channel 1 configuration menu. Note: If it is desired to reset the SQUID so that the output is nulled for a given circumstance, this may be accomplished by navigating to the "reset" option in the channel 1 configuration menu and toggling the reset on and then off. Also note: <u>A calibration table can be found on the back of the constant current source.</u>

Record the measured value of output voltage / calibration current:_________V/mA

Calibration note: The central field produced by the helmholtz calibration coil is calculated to be 0.283 Gauss/Amp in free space and by numerically correcting for the shielding currents is found to be <u>0.278 G/A in a 10" shield</u> (a 1.8% reduction).

Using this gauss/amp value, record the approximate magnetometer calibration factor: applied B field / output voltage = _____________ mG/V (500 range). Note: This calibration factor is approximate because the pickup coil may not be exactly aligned. A calibration which should be more precise is done below.

L.3.8 Turn the current pot to zero and turn off the current source.

L.4 Field measurement

L.4.1 On the computer, cd to C:\FLIP

L.4.2 Specify the program name used to make measurements (e.g., flipcl2): __________________, rev. date:__________________.

L.4.3 Launch the field measurement program and enter S to perform a scan.

L.4.4 Pick a file name and enter this and the other requested information in Table 1.

L.4.5 The magnetometer will run the flip coil 360° and then reverse direction and run back to 0°. The display will plot the signal with the ordinate axis range being ±5 V and abscissa being 360° and with the trace and retrace being in contrasting colors.

L.4.6 Press the Print Screen key on the computer to produce a hard copy of the screen. This should be attached to this procedure upon completion. Also verify that all the required information is entered in Table 1.

L.4.7 If necessary, adjust the Range and Gain settings in order to obtain a signal that is a reasonable fraction of the maximum output voltage, and repeat steps L.4.3 - 4.8. To change SQUID range or amplifier gain factors, press the escape key on the QD controller to allow local control. Go to the channel 1 configuration screen and select new values.

L.5 In Situ Calibration:

L.5.1 Connect / verify connected the helmholtz calibration coil as in L.3.5 and 3.6.

L.5.2 Adjust constant current supply to a current that produces a field > 10 times the approximate field amplitude measured in step L.4. Adjust the SQUID gain and range factors as necessary

L.5.3 Run the field measurement program as in step L.4. If the field measured in step L.4 was transverse (i.e., being sinusoidal rather than cosinusoidal), the data obtained from this measurement should represent a calibration to within ~1% or to within the accuracy of the calibration B/I factor listed in L.3.6, whichever is greater. If in the unlikely event the ambient field is axial (cosinusoidal) in nature, the calibration factor obtained in L.3.6 is probably more accurate. Note calibration result (volts/µg) in the comments column of Table 1.

L.5.4 Turn the current pot to zero and turn off and disconnect the current source.

L.6 Alternate transverse field measurement technique:

L.6.1 If the field measurement technique described in L.4 does not produce a clean reproducible sinusoid, it is likely that there is too much trapped flux in the pickup circuit. If this is the case, the transverse (x-y) component of the ambient field can be measured by manually rotating the RCM about its vertical axis while recording data on a chart recorder as a function of time. <u>Even if the technique in L.4 appears to produce a good result, the following measurement should be performed at least once for corroboration</u>. Note: Due to the possibility of magnetic remanence associated with the RCM, the technique in L.4 can determine the ambient transverse field only after all four azimuthal directions (±X, ±Y) are measured at a given location. See L.7.

L.6.2 Orient / verify oriented the RCM azimuth along the +X axis.

L.6.3 Connect / verify connected the helmholtz calibration coil as in L.3.5 and 3.6.

L.6.4 Set the QD gain and range to that used in L.5.2 and null the output as described in L.3.6

L.6.5 Set up the chart recorder:

L.6.5.1 Select a channel and zero the corresponding pen at the center of the chart.

L.6.5.2 Set the channel gain setting to 10 V f.s. (100 x 0.1 V).

L.6.5.3 Verify that the chart recorder preamp cal-var switch is set on "cal".

L.6.5.4 Connect the analog output of the QD magnetometer to one of the input channels of the Soltec chart recorder and activate the channel.

L.6.6 Verify strip chart recorder calibration:

L.6.6.1 Verify that the magnetometer is zeroed and lower the appropriate chart pen onto the paper.

L.6.6.2 Turn on and increase the output of the current source until the QD readout indicates 5.00 V. Write a notation on the chart paper that the pen deflection is 5.00 volts. Lift the pen.

L.6.7 Manually adjust the pickup coil orientation to approximately 90° (such that the coil is sensing the transverse field). While varying the current supply up and down, slowly adjust the coil orientation until no response is seen in the magnetometer. This will ensure that the pickup coil sensing direction is transverse to the RCM vertical axis.

L.6.8 Turn the current pot to zero and turn off and disconnect the current source.

L.6.9 Set the QD range and gain to values appropriate for the expected signal, e.g. range 5S and gain 10X for a field level of 0.1 µg or less, and renull the QD output if necessary.

L.6.10 Set the chart speed at 20 cm/min (do not start recording) and the recorder gain setting at an appropriate value (e.g. at 1 V f.s. for a field level of 0.1 µg or less). Record the following information on the strip chart: Date, time, chart speed, QD range and gain, gyro position number, RCM azimuth and coil orientation (e.g., +X axis, transverse sense), and the direction the RCM is to be rotated (e.g., CCW).

NOTE:

In the following step, one person will be manually rotating the RCM about its vertical axis. Care should be exercised to rotate as uniformly as possible without applying any lateral force which could displace the pickup coil away from center. Lateral displacement can cause a spurious signal due to the possibility of a field gradient at the pickup coil.

L.6.11 Station one person on the glovebox support plate to rotate the magnetometer. Loosen the 2" QC ring sufficiently for the RCM to be able to rotate freely. Start the chart recorder running and after a few seconds of operation to establish a baseline, the person on the glovebox support plate should start rotating the magnetometer in the agreed-upon direction at a rate of 20-30 seconds per quarter revolution. Every 45 degrees, the person rotating the magnetometer should announce the azimuthal angle which should then be marked on the chart. Rotation should be stopped after one complete revolution. Let the chart recorder continue running for a few more seconds and then put the recorder on standby. Log the measurement in Table 1 with a note in the comment column "manual RCM rotation".

L.6.12 If this alternate measurement technique has successfully corroborated the results from L.4, and the standard method is producing acceptable results, proceed to L.7 to continue with the standard technique

L.6.13 If the standard method is not producing acceptable results, skip to L.7.2 to change the RCM Z position to a new gyro location and continue with L.6.13.

L.6.14 Repeat L.6.9 through L.6.12 until all four gyro locations have been measured.

L.7 Additional field measurements: Change the azimuth and/or Z position as described below and repeat steps L.4.3 - 4.9 as required. In general, four azimuth measurements (in the ±X*, ±Y* directions) should be made for each Z position (unless it is clear that the alternate technique described in L.6 is to be used in place of L.4), and measurements at all four gyro locations should be performed.

L.7.1 To change azimuth: Loosen 2" QC ring, rotate magnetometer by hand to the new orientation, and retighten QC ring.

L.7.2 To change vertical position:

L.7.2.1 Verify that the crane has been inspected for proper operation within the previous seven days.

L.7.2.2 Using the compliance device with the alarm, connect the crane to the RCM lifting eye.

L.7.2.3 Loosen the 2" QC ring completely and pull o-ring away from the QC body.

L.7.2.4 Using the crane, move the RCM to a position slightly above the new position, making sure that the 3" protection housing does not move. Guide the equalization hose and electrical cables to prevent snagging.

L.7.2.5 Loosen the yoke from the guide rods and the 2" RCM housing and raise until it is in the next desired gyro location as given in Fig. 1. Reclamp onto the guide rods.

L.7.2.6 Orient the RCM to the correct azimuth and lower onto the yoke. Retighten the yoke to the RCM as necessary.

L.7.2.7 Retighten the 2" QC.

L.7.2.8 Lower and detach the crane from the lifting eye.

L.8 Axial field gradient measurement. If the alternate transverse field measurement technique of section L.6 was performed in lieu of L.4, perform the following steps to acquire information on the longitudinal field component:

L.8.1 Use the steps L.7.2.1 - L.7.2.5, lower the RCM to a position 1" below gyro 4 position (STA 142.6, i.e., the height of the bottom of the cross brace above the split clamp ring should be 7.20"). Do not retighten the 2" QC or detach the crane.

L.8.2 Adjust the pickup coil orientation until the turns counting dial on the drive shaft housing reads ~065 so that the coil is now sensing the axial field component.

L.8.3 Set the QD range and gain parameters to the same values used in L.6, and null the SQUID output.

L.8.4 Set the chart speed at 20 cm/min (do not start recording) and the recorder gain setting at an appropriate value (e.g. at the same used in L.6). Record the following information on the strip chart: Date, time, chart speed, QD range and gain, starting position pickup coil position (STA 142.6), RCM coil orientation (axial sense), and the direction the RCM is to be moved (upward).

L.8.5 Station one person on the glovebox support plate to measure the magnetometer location and operate the crane. Verify that the RCM is free to move. Start the chart recorder running and after a few seconds, start the crane lifting upward at its slowest speed. The person measuring the RCM position should announce every inch of motion and that information should be marked on the strip chart. Position measurement should be done in such a way as to not perturb the motion of the RCM. After 12" of motion, stop the crane and continue to let the chart recorder operate for a few more seconds before stopping.

L.9 Terminate RCM measurements:

L.9.1 Turn off power to SQUID controller, motor controller, computer, and printer.

L.9.2 Disconnect all cables to the RCM.

L.10 Verification documentation:

L.10.1 Verify that Table 1 is completely and accurately filled out.

L.10.2 Attach to this procedure any strip chart data or printed data plots acquired for requirement verification.

L.10.3 Enter analysis document cross reference (if any):____________________________

Test completed.

Completed by: __________________
Witnessed by: __________________
Date: __________________
Time: __________________

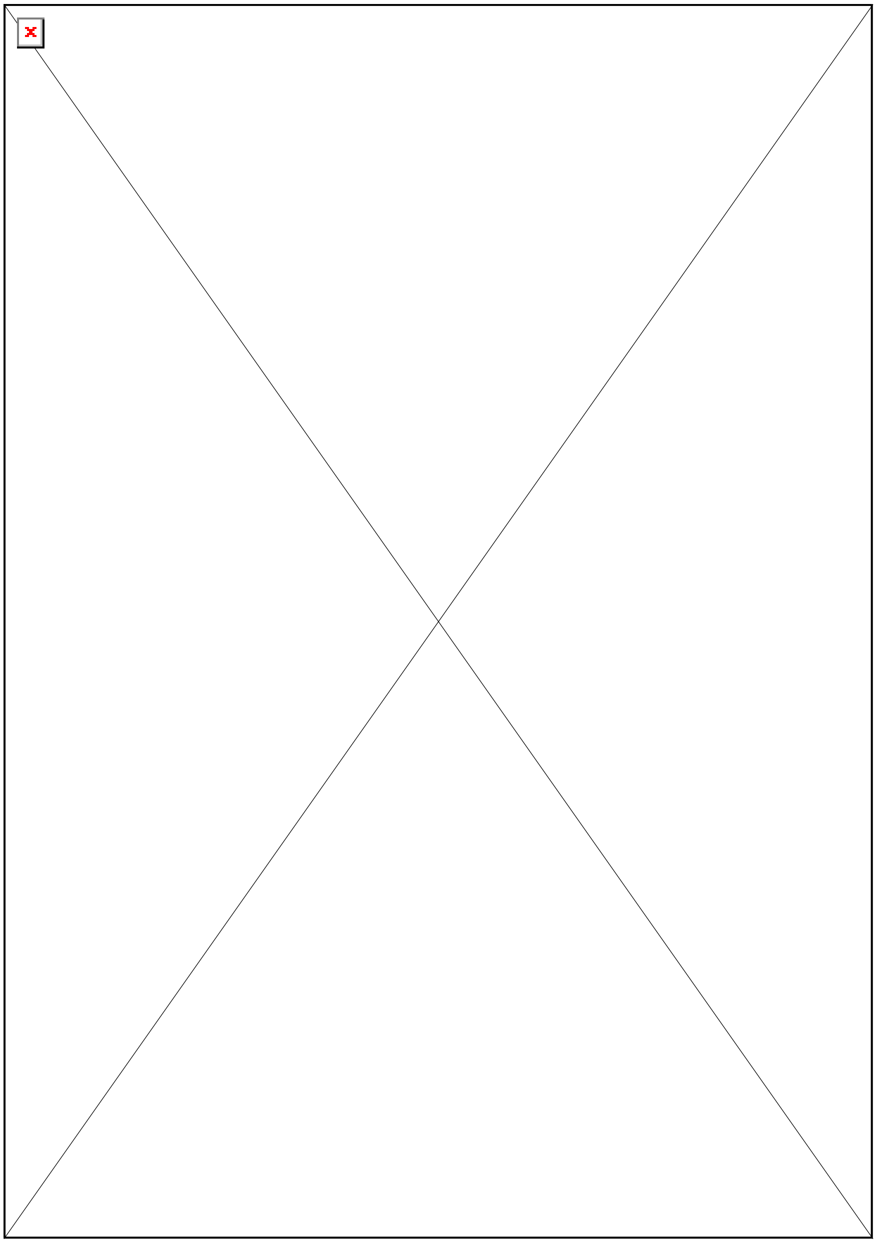

Fig. 1 RCM position reference. The dimensions shown are the height of the bottom of the cross brace above the split clamp ring. The highest position places the rotating coil at the position of gyro 1 (STA 153.3), the second position, gyro 2 (STA 150.1), third, gyro 3 (STA 146.8), and lowest, gyro 4 (STA 143.6).

Table 1

Date	Time	File name	Coil z position (STA No.)[1]	Azimuthal angle[2]	Range	Gain	Comments

[1] Station number of the pickup coil. See Fig. 1 caption for the correlation between the measured position and the pickup coil location.
[2] Angle of the sensing axis in degrees from the +X* axis so that 90° is in the +Y* direction.

Table 1 (cont'd)

Date	Time	File name	Coil z position (STA No.)	Azimuthal angle	Range	Gain	Comments