BRI-ACE-108

ACE Observatory-Level Static Magnetic Field Test Procedure

Version 1

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ACE Static Field Procedure Document Changes		
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Note to the reader: The mag sniffer locations as called out in the test procedure are designed to be appropriate to the size of the ACE spacecraft and distribution of the known and expected magnetic sources. The MAG team wishes to reserve the right to reposition the sensors during the tests in order to better determine the static magnetic field of the observatory. The translation and rotation spacings may also be subject to review as the test proceeds, although the range of the spacecraft translation is not expected to change. APL personnel are welcome to be present for the test, and are expected to supervise the handling of the spacecraft.

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1 Test Description

1.1 Scope

The observatory-level static magnetic field measurement determines the total static (DC) field of the laboratory, including all its components. Since access to the GSFC magnetics facility is still not supported by the management team, this alternate and inferior test will be performed in Earth's field in one of the high bays at GSFC. The measurements will be of a different nature, being referenced to a background level and to each other. For this reason, it is important that the measurements be done in a manner and at a time which will minimize fluctuations in the background levels. This means on a weekend or holiday at off-shift hours, when local traffic and operations are at a minimum. The test is made using a set of portable magnetometers provided by the MAG instrument team.

1.2 Purpose

The purpose of the procedure is to measure the total static or DC magnetic field component of the observatory in the flight configuration. During the manufacture and assembly of the laboratory, the component sub-assemblies were magnetically screened (and deGaussed when necessary and permitted). This process is described in the Integration and Test Plan BRI-ACE-008. The results of this screening are used in a model of the laboratory magnetic signature which the MAG team periodically updates. The static measurements performed in this procedure will be used to validate the magnetic model and confirm the expected magnetic values. The DC magnetic field goal for the ACE laboratory is less than 0.1 nT at the MAG sensor positions, mounted at the ends of the booms extended along the Y-axis.

Even with the performance of this test at a time of relative quiet, the background magnetic noise levels and the inaccuracies inherent to this simplified magnetic characterization are expected to limit determination of the spacecraft static field at the (deployed) MAG sensor to ± 0.5 nT. If the spacecraft field is time-indepenent, which will not be know until flight, we believe that a static field of 0.5 nT at the deployed sensors will not adversely impact the science.

1.3 Heritage

This same test procedure, or variations upon it, have been performed on the WIND, POLAR, and XDE spacecraft and are currently planned for TRIM and MGS. The WIND and POLAR tests were performed at the East Windsor facility while the XDE test was performed in the high bay at GSFC. The TRIM test is currently scheduled for the GSFC high bay while MGS will be measured in Denver.

2 Test Instruments and Conditions

The ACE observatory-level static field test is presently scheduled to be performed in one of the GSFC high bay facilities when the spacecraft is in transit to or from GSFC test facilities. The GSFC high bay has been chosen because (1) it is larger than the APL facility, (2) the steel of the crane is further removed from the test proximity, and (3) it has been the site of an earlier similar and successful test of the XDE spacecraft.

It is aniticipated that the spacecraft will be free of non-flight hardware in order that this test may accurately resolve the field of the spacecraft in its flight configuration. Any non-flight hardware that will be attached to the spacecraft at this time must be discussed with the MAG team and screened for magnetization, but it is highly desirable that such materials be kept to a minimum. Any flight hardware not attached to the spacecraft at this time must also be identified and tested separately.

It is aniticipated that the solar arrays and MAG booms will not be attached to the spacecraft at this time. Therefore, the static field of the solar arrays will be tested separately.

2.1 Description of Magnetometer

The sniffing magnetometer consists of a portable (PC compatible) computer with operator keyboard, an electronics interface box, and a 3-axis magnetic field sensor. The sensor's outer dimensions are approximately 6 inches by 3 inches by 3 inches high. It may be placed at or near the region of interest. It takes readings in each axis, at a sample rate of 12 samples per second, and a frame rate of 2 frames per second. It measures either absolute or delta field levels from 1 nanoTesla (nT) to 82,000 nT (0.82 Gauss). It records all readings in a computer file, with a maximum of 9,000 frames (4,500 seconds) per file.

Several of these instruments, located at different locations described in Section 4.1, will be used during this procedure to obtain the required data. Simultaneous measurements with several sensors at different locations permit the first order removal of background variations.

3 Magnetic Measurements

The magnetic measurements will be divided into two parts. The first part is a set of measurements to measure the dependence of the spacecraft magnetic field with distance. During this test, the spacecraft is suspended from the crane with the hook as far above the spacecraft as possible. The crane hook is held at a fixed location while a set of measurements is taken as the spacecraft is slowly moved by hand toward the test magnetometers from a distance of 6 feet. (The 6 foot translation can be accomplished either by moving the spacecraft 6 feet from the vertical position, or from -3 to +3 feet from vertical. The resulting measurement is equally valid in either scheme.) The spacecraft is stopped at 2 foot intervals and the field measurements are recorded. The spacecraft is then rotated by 90°, 180° and 270° and the operation is repeated for each orientation. (This also provides limited angular information.)

The second set of measurements is designed to measure the angular dependence of the static field. During this test the spacecraft is suspended from the crane directly under the hook and rotated about a fixed axis at a fixed position. Measurements are made at 30° increments over a 360° rotation. The measurements are performed for two complete rotations of the spacecraft.

The time required to record useful and accurate measurements of the magnetic field at each station is nominally only 5 to 10 seconds, but in practice it will depend in large part on the background conditions and the ability of the assembled team to work together efficiently. There is an advantage to making quick and precise measurements at each of the prescribed positions as the background field may be variable over the duration of the measurement. (It is desirable to record a series of measurements while the background field is stationary.) However, it is most important to record the magnetic measurements when the spacecraft is accurately positioned while the safe handling of the observatory is paramount.

3.1 Magnetic Measurement Setup

The spacecraft should be hung with nonmagnetic materials, including any spacer bar and fasteners required by the support harness. The X- and Y-axes of the spacecraft should be marked, or agreed upon by all in attendance, as the test operations will refer to these orientations. A preliminary measurement of the crane and hook assembly will be required to verify that movement of the heavy steel can be sufficiently minimized as to provide a useful diagnostic of the spacecraft field. The MAG team can perform this operation well in advance, following discussions with APL engineers designing the lifting hardware.

Before the measurement, all non-flight hardware that can be removed from the spacecraft should be removed. The MAG team will need to screen all non-flight hardware that is expected to be attached to the spacecraft during the static field test. If the field from the combined attached non-flight sources is comparable to or exceeds the anticipated spacecraft field or spacecraft magnetic goal this test will not be successful since it will only result in the analysis of non-flight hardware. Removal of the non-flight hardware analytically from

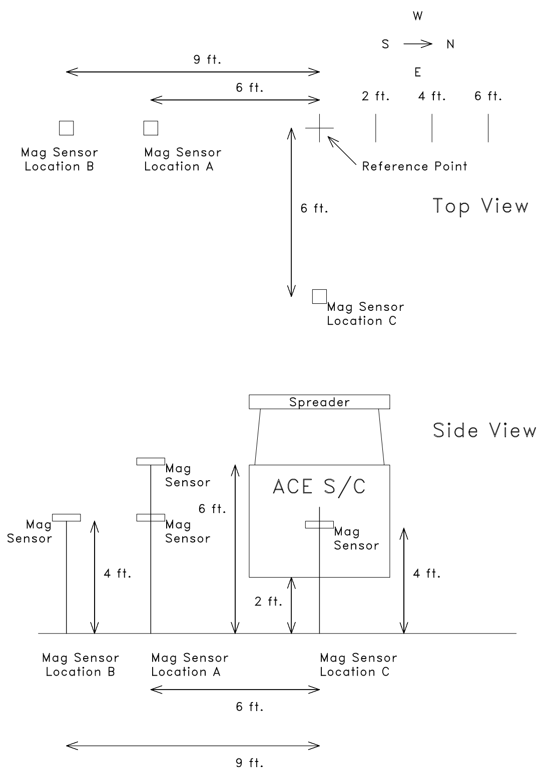

Figure 1: Laboratory Configuration for Translation Test

the measured field may be possible, but will require magnetic characterization to the same degree that the spacecraft field will be characterized in this test.

During testing, large metal objects such as tables, tool boxes, etc. should be removed from the immediate area of the test. If they cannot be removed, they should remain at the same location and in the same orientation for the different phases of the procedure.

3.2 Spacecraft Magnetic Measurements – Translation Test

Figure 1 shows the locations of the magnetometers and spacecraft for the distance-dependent measurements. The spacecraft should be centered over the locations indicated when the measurements are made. The location of equipment in the bay should be the same during all phases of the test.

The spacecraft is hung over the reference point with a known and specified orientation. It is then moved by hand by the assembled technicians to a series of points that are 2, 4 and 6 feet from the reference point and held at each location while the measurements from each magnetometer are recorded.

All magnetic data should be recorded on floppy disks marked with the ID number, date, time and magnetometer identification number.

3.3 Spacecraft Magnetic Measurements (0° orientation)

1. Attach the spacecraft to the handling and suspension hardware per APL direction.

   Nonmagnetic handling procedure agreed upon: ________________________

2. Raise the spacecraft to the height shown in Figure 1. The hook height and location of crane control box should be the same for all measurements.

   Spacecraft height from floor: ________________________

   Approximate hook position above spacecraft: ________________________

3. Position the spacecraft with the +X–axis toward the selected reference position, at the furthest position (6 feet) indicated in Figure 1 and record all magnetometer readings.

   Spacecraft positioned and held still at 6 feet: ________________________

4. Re-position the spacecraft by translation to 4 feet from the reference position as indicated in Figure 1 and record all magnetometer readings.

   Spacecraft positioned and held still at 4 feet: ________________________

5. Re-position the spacecraft by translation to 2 feet from the reference position as indicated in Figure 1 and record all magnetometer readings.

   Spacecraft positioned and held still at 2 feet: ________________________

6. Re-position the spacecraft to the reference position as indicated in Figure 1 and record all magnetometer readings.

   Spacecraft positioned and held still at reference position: ________________________

7. Reposition the spacecraft at the original test position (6 feet from the reference position) and record all magnetometer readings. If the readings match the earlier values, the above measurements are accepted and the test proceeds. If the values do not match to within 5 nT, or if a change in the background was perceived during the previous test sequence, the sequence is repeated whole or in part. (Background changes by more than 5 nT will invalidate a test sequence with large-scale drifts being more serious than short bursts.)

3.4 Spacecraft Magnetic Measurements (90° orientation)

1. Attach the spacecraft to the handling and suspension hardware per APL direction.

   Nonmagnetic handling procedure agreed upon: ________________________

2. Raise the spacecraft to the height shown in Figure 1. The hook height and location of crane control box should be the same for all measurements.

   Spacecraft height from floor: ________________________

   Approximate hook position above spacecraft: ________________________

3. Position the spacecraft with the +Y–axis toward the selected reference position, at the furthest position (6 feet) indicated in Figure 1 and record all magnetometer readings.

   Spacecraft positioned and held still at 6 feet: ________________________

4. Re-position the spacecraft by translation to 4 feet from the reference position as indicated in Figure 1 and record all magnetometer readings.

   Spacecraft positioned and held still at 4 feet: ________________________

5. Re-position the spacecraft by translation to 2 feet from the reference position as indicated in Figure 1 and record all magnetometer readings.

   Spacecraft positioned and held still at 2 feet: ________________________

6. Re-position the spacecraft by translation to the reference position as indicated in Figure 1 and record all magnetometer readings.

   Spacecraft positioned and held still at reference position: ________________________

7. Reposition the spacecraft at the original test position (6 feet from the reference position) and record all magnetometer readings. If the readings match the earlier values, the above measurements are accepted and the test proceeds. If the values do not match to within 5 nT, or if a change in the background was perceived during the previous test sequence, the sequence is repeated whole or in part. (Background changes by more than 5 nT will invalidate a test sequence with large-scale drifts being more serious than short bursts.)

3.5 Spacecraft Magnetic Measurements (180° orientation)

1. Attach the spacecraft to the handling and suspension hardware per APL direction.

   Nonmagnetic handling procedure agreed upon: ________________________

2. Raise the spacecraft to the height shown in Figure 1. The hook height and location of crane control box should be the same for all measurements.

   Spacecraft height from floor: ________________________

   Approximate hook position above spacecraft: ________________________

3. Position the spacecraft with the -X–axis toward the selected reference position, at the furthest position (6 feet) indicated in Figure 1 and record all magnetometer readings.

   Spacecraft positioned and held still at 6 feet: ________________________

4. Re-position the spacecraft by translation to 4 feet from the reference position as indicated in Figure 1 and record all magnetometer readings.

   Spacecraft positioned and held still at 4 feet: ________________________

5. Re-position the spacecraft by translation to 2 feet from the reference position as indicated in Figure 1 and record all magnetometer readings.

   Spacecraft positioned and held still at 2 feet: ________________________

6. Re-position the spacecraft by translation to the reference position as indicated in Figure 1 and record all magnetometer readings.

   Spacecraft positioned and held still at reference position: ________________________

7. Reposition the spacecraft at the original test position (6 feet from the reference position) and record all magnetometer readings. If the readings match the earlier values, the above measurements are accepted and the test proceeds. If the values do not match to within 5 nT, or if a change in the background was perceived during the previous test sequence, the sequence is repeated whole or in part. (Background changes by more than 5 nT will invalidate a test sequence with large-scale drifts being more serious than short bursts.)

3.6 Spacecraft Magnetic Measurements (270° orientation)

1. Attach the spacecraft to the handling and suspension hardware per APL direction.

   Nonmagnetic handling procedure agreed upon: ______________________

2. Raise the spacecraft to the height shown in Figure 1. The hook height and location of crane control box should be the same for all measurements.

   Spacecraft height from floor: ______________________

   Approximate hook position above the spacecraft: ______________________

3. Position the spacecraft with the -Y–axis toward the selected reference position, at the furthest position (6 feet) indicated in Figure 1 and record all magnetometer readings.

   Spacecraft positioned and held still at 6 feet: ______________________

4. Re-position the spacecraft by translation to 4 feet from the reference position as indicated in Figure 1 and record all magnetometer readings.

   Spacecraft positioned and held still at 4 feet: ______________________

5. Re-position the spacecraft by translation to 2 feet from the reference position as indicated in Figure 1 and record all magnetometer readings.

   Spacecraft positioned and held still at 2 feet: ______________________

6. Re-position the spacecraft by translation to the reference position as indicated in Figure 1 and record all magnetometer readings.

   Spacecraft positioned and held still at reference position: ______________________

7. Reposition the spacecraft at the original test position (6 feet from the reference position) and record all magnetometer readings. If the readings match the earlier values, the above measurements are accepted and the test proceeds. If the values do not match to within 5 nT, or if a change in the background was perceived during the previous test sequence, the sequence is repeated whole or in part. (Background changes by more than 5 nT will invalidate a test sequence with large-scale drifts being more serious than short bursts.)

3.7 Translation Test Data Sheet

Magnetometer ID: ____________ Location: ________________________

Distance	Angle	Time	Flux	Flux Δ
6 feet	0°	____________	____________	____________
4 feet	0°	____________	____________	____________
2 feet	0°	____________	____________	____________
0 feet	0°	____________	____________	____________
6 feet	0°	____________	____________	____________
6 feet	90°	____________	____________	____________
4 feet	90°	____________	____________	____________
2 feet	90°	____________	____________	____________
0 feet	90°	____________	____________	____________
6 feet	90°	____________	____________	____________
6 feet	180°	____________	____________	____________
4 feet	180°	____________	____________	____________
2 feet	180°	____________	____________	____________
0 feet	180°	____________	____________	____________
6 feet	180°	____________	____________	____________
6 feet	270°	____________	____________	____________
4 feet	270°	____________	____________	____________
2 feet	270°	____________	____________	____________
0 feet	270°	____________	____________	____________
6 feet	270°	____________	____________	____________

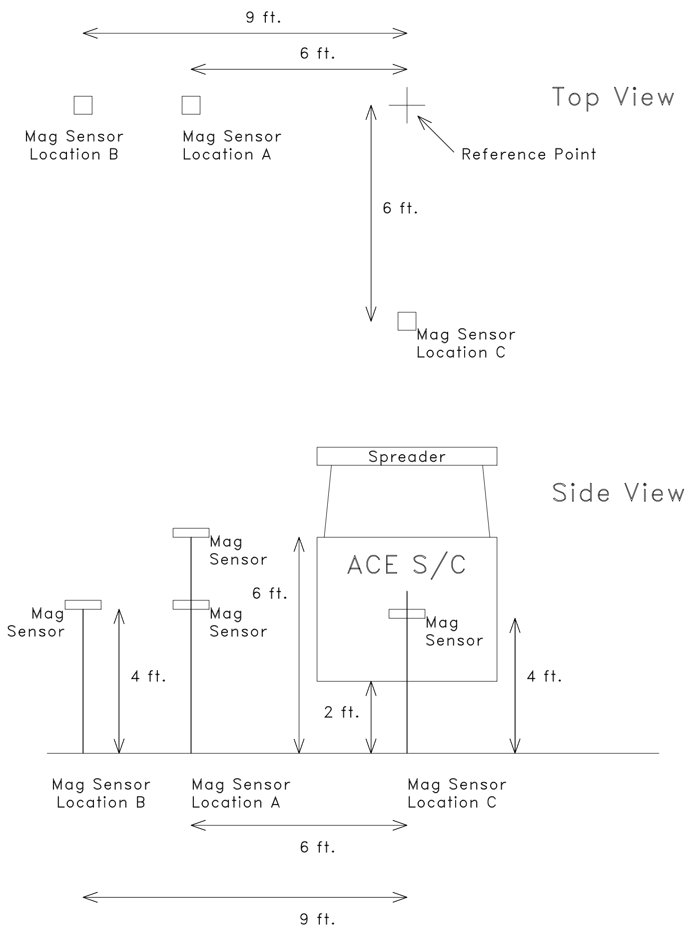

Figure 2: Laboratory Configuration for Rotation Test

3.8 Magnetic Measurements as a Function of Angle

This set of measurements is designed to determine the azimuthal variations in the observatory's magnetic field. During these measurements, the observatory is suspended above the floor using the overhead crane and spacecraft sling. While suspended, the observatory will be rotated by hand through 360° in 30° increments. Figure 2 shows the test configuration for the rotation part of the measurements.

3.9 Spacecraft Magnetic Measurements – Rotation Test

1. Lift the spacecraft from the spacecraft dolly to the height shown in Figure 2.

   Nonmagnetic handling procedure agreed upon and inacted: ________________________

2. While suspended from the sling and centered over the reference point, make a series of measurements as the spacecraft is rotated. Measurements should be made at 30° intervals. The angular locations should be marked on the floor to facilitate the repeat measurements with the spacecraft. Magnetometer readings should be made at 30° increments in angular rotation. (Viewed from the top, angles increase clockwise as listed on the Angular Rotation Test Sheet.) The measurements should be made for two complete rotations. Record the measurements on the Angular Rotation Test Sheet that follows.

   Spacecraft height from floor: ________________________

   Approximate hook position above spacecraft: ________________________

3. Place spacecraft on the dolly and remove the spacecraft dolly from the immediate vicinity of the test (30 feet) and make another background level measurement.

   Spacecraft removed to: ________________________

4. Repeat any measurements which are adversely affected by changes in the background levels; i.e., background level changes in excess of 5 nT.

5. Prepare a table of magnetometer readings for each orientation. The values should be normalized for the background level and changes from the previous location.

3.10 Rotation Test Data Sheet

Magnetometer ID: ____________ Location: ________________________

	First Rotation		Second Rotation	
Angle	Flux	Time	Flux	Time
0°				
30°				
60°				
90°				
120°				
150°				
180°				
210°				
240°				
270°				
300°				
330°				
360°				

The measurements should be done as quickly as possible to minimize the effects of changes in the background levels.

Repeat any measurements which are adversely affected by changes in the background levels; i.e., background level changes in excess of 5 nT (drifts are more serious than short bursts which can be identified and return to the same level.)

3.11 Rotation Test Reduction Sheet

Magnetometer ID: ____________ Location: ________________________

	First Rotation		Second Rotation	
Angle	Field	Field Δ	Field	Field Δ
0°	____________	____________	____________	____________
30°	____________	____________	____________	____________
60°	____________	____________	____________	____________
90°	____________	____________	____________	____________
120°	____________	____________	____________	____________
150°	____________	____________	____________	____________
180°	____________	____________	____________	____________
210°	____________	____________	____________	____________
240°	____________	____________	____________	____________
270°	____________	____________	____________	____________
300°	____________	____________	____________	____________
330°	____________	____________	____________	____________
360°	____________	____________	____________	____________