Note: This document was archived with the PDS3 NEAR Magnetometer data sets with a publication date of 2001 and no further information on date or authorship.

Calibration of NEAR Magnetometer Data

Calibration of the magnetometer data consisted of two major steps. The first step was to evaluate the basic sensor response to the known field in the pre-flight environment. The second step was to evaluate the sensor alignments and spacecraft field in the in-flight environment. The details of these steps have been described by Lohr et al. [1997] and Anderson et al. [2001], respectively. Here we present a brief summary of the results from these publications. The software packages, mag_sdc_proc.doc and mag_sci_proc.doc, used for data reduction have been included as an example of an algorithm for the data reduction methodology.

1. Pre-flight results

The pre-flight calibration evaluated the linearity, orthogonality and cross talk of the sensor block for each axis and each dynamic range. Table 1 shows the list of the linearity tests performed for ranges 7 through 3 at GSFC and for ranges 7 through 0 at APL. Pre-flight sensor calibration provided absolute gain calibrations to 0.1% (0.5%) in the least (most) sensitive range and orientation to 1 arc minute.

Table 1 Conversion from counts to nT.
(Table 2 of Lohr et al. [1997])

NEAR Magnetometer Calibration: Counts/nT (20 bit Values)

Range	Component	GSFC Result	APL Result	% Dev.
0	X		124850+/-1300	
	Y		126700+/-920	
	Z		125700+/-1400	
1	X		32320+/-55	
	Y		32316+/-66	
	Z		32596+/-24	
2	X		7927.5+/-6.3	
	Y		7981.2+/-6.7	
	Z		8015.5+/-2.9	
3	X	2019.3	2020.0	-0.035
	Y	2027.1	2027.5	-0.020
	Z	2038.8	2040.3	-0.074
4	X	509.90	510.06	-0.031
	Y	508.94	508.85	0.018
	Z	513.12	513.61	-0.095
5	X	129.75	129.83	-0.062
	Y	129.34	129.32	0.015
	Z	130.51	130.66	-0.115
6	X	31.867	31.872	-0.016
	Y	31.869	31.871	-0.006
	Z	32.087	32.106	-0.059
7	X	8.1103	8.1143	-0.049
	Y	8.1010	8.1030	-0.025
	Z	8.1616	8.1717	-0.124

2. In-flight results

2.1. Final adjustment matrix

In-flight data, including those acquired during the Earth swing-by of January 22-23, 1998, were used to obtain the gain factors and the precise sensor orientation. From comparison of the measured and IGRF-1995 model magnetic fields for the swing-by period, the final adjustment matrix in the spacecraft coordinates was determined to be:

$$\begin{pmatrix} B_x \\ B_y \\ B_z \end{pmatrix}_{\text{Final-SC}} = \begin{pmatrix} 1.0005 & 0.0314 & 0.0018 \\ -0.0251 & 0.9999 & 0.0073 \\ -0.0039 & -0.0038 & 0.9996 \end{pmatrix} \cdot \begin{pmatrix} B_x \\ B_y \\ B_z \end{pmatrix}_{\text{Obs–SC}} \quad (1)$$

To obtain the final vector fields (Bx, By, Bz)Final-SC, one converts the raw data (counts) from each sensor using the conversion factors defined in Table 1, removes spacecraft fields described in the following section to obtain (Bx, By, Bx)Obs-SC, and then use the matrix operation defined in Equation (1).

2.2. Spacecraft fields

The spacecraft fields evaluated after launch are summarized in Table 2, which is taken from Anderson et al. [2001]. The following is a brief description of the sources of spacecraft fields.

2.2.1. Magnetic latching valves

The static magnetic field is due mostly to the magnetic latching valves used in the propulsion system. The field was reduced to less than 200 nT by placing two permanent magnets on the top deck. Long-term cruise measurements determined the field to an accuracy of 0.5 nT.

2.2.2. Terminal board

All loads on the spacecraft are powered through the terminal board. The wiring makes an uncompensated current loop of 100 cm**2 to 600 cm**2 and produces variable magnetic fields. The total magnitude of the field is 30 to 50 nT and changes stepwise.

2.2.3. Power management system

The power system includes the solar arrays and cabling, and the power shunt control circuitry. The total array counts ranges from 15 to 60 amperes giving a variation in the observed field as large as 38 nT. This variation is corrected to a precision of about 1.5 nT in each component by using the following relationship between the solar array current and the field variations, where one ampere equals 3.4 counts.

$$\begin{pmatrix} \Delta BX \\ \Delta BY \\ \Delta BZ \end{pmatrix} = \begin{pmatrix} -0.020 \pm .011 \\ +0.163 \pm 0.016 \\ -0.259 \pm 0.011 \end{pmatrix} \text{nT/count} \qquad (2)$$

Current shunting is done in two levels, digital (stepwise) and analog (continuous) [Jenkins et al., 1995]. It is possible to remove the contamination fields from the currents because both the total solar array currents and digital and analog shunt currents are recorded.

2.2.4. Momentum wheels

Four momentum wheels are included in the spacecraft attitude control system for three-axis stabilization and precision pointing. The wheels produces sinusoidal signals with ~1 nT peak to peak amplitude. The contamination from the wheels can be avoided by filtering out the rapid variation.

Table 2. Sources of variable spacecraft magnetic fields together with their approximate magnitude, characteristic time scale and type signal.

Source	**Magnitude**	**Time scale**	**Type of signal**	**Mitigation approach**
Propulsion valve motion.	~100 nT	Propulsion events	Discrete pairwise jumps – zero net change.	Flag propulsion events. Correcting data during propulsion events not necessary.
Terminal board: all spacecraft loads	25 nT	~10 min. (heaters) <1 s (NLR)	Variable baseline with discrete jumps.	Field is directly proportional to load currents monitored in spacecraft engineering data. Loops measured during assembly.
Digital power system shunts*	5-10 nT	Hours to months	Discrete jumps.	Ratio between digital shunt and total solar array current identifies shunt step. Field fixed in each level.

Analog power system shunts*	5 nT	Minutes	Gradual variations with intermittent discrete jumps.	Field is proportional to analog current within each of segments in analog shunt current corresponding to the six analog shunt resistors on the SC.
Solar arrays	30 nT	Hours to months	Gradual shift with discrete jumps.	Field is directly proportional to total solar array current. Independent of digital shunt level.
Momentum wheels*	1-2 nT	0.2 to 10s Hz, usu. > 0.5 Hz	Superposition of four sinusoids corresponding to rotation rates of four wheels.	Benign - wheel speeds kept above 0.5 Hz & monitored in engineering data. Speeds < 0.5 Hz occur during maneuvers. MAG 0.5 Hz filter eliminates contamination. 1/s sampling allows additional filtering if needed.

* Sources either discovered after launch or found to be stronger than expected.

References

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