Calibration of the fluxgate CSC vector magnetometers

This report shows the results of the calibration of the flight and flight spare CSC magnetometers for the Ørsted satellite. The instrument shows an outstanding behavior as regards of both constant temperature and temperature depance. Neither transverse effects nor non-linear terms have been found. The non-linearity is less than 4.0 ppm, taking into account that the coil facility where the magnetometer has been scanned has a very low noise (0.5 nT p-p) but not sufficient low to precise much more in this parameter. There is no non-linearity over the entire temperature range. The sensor offsets are less than 2.0 nT and 10.0 nT for the flight and flight spare electronics, respectively. They have been determined by two procedures which give consistent results. Firstly, as output in the spherical harmonic method, and secondly, by rotation of the CSC sensor by 180° in two axes. It does not change with temperature. The sensitivities are different in each axis, due to the fact that any ADC has its own voltage reference and there is a slight difference between them. They change linearly with temperature. The temperature coefficient for each sensor is different since the radius of the feedback coil is bigger for sensor 1 than sensor 2, and bigger for sensor 2 than sensor 3. They are 13.3 ppm/°C, 10.2 ppm/°C and 6.8 ppm/°C for sensor 1, 2 and 3, respectively in the flight unit. And 36.8 ppm/°C, 34.2 ppm/°C and 31.7 ppm/°C for sensor 1, 2 and 3, respectively in the flight spare unit. The difference between flight and flight spare units reflects the different constructions. The sensor offset and sensitivity change, depending on which of the ADC’s or which electronic box is used with the sensor. The non-orthogonal angles are defined as the error respect to 90°, so angle1=-90°, angle2=90°- and angle3=90°-. In the flight unit they are 317.3, 113.3 and -34.3 arc sec, respectively. And 65.8, -195.8 and 406.3 arc sec, respectively, for the flight spare unit. They do not change with temperature within 0.5 arc sec. of r.m.s. deviation. The SIM turned out to change the sensitivities of the CSC sensor giving an error corresponding to 5 to 10 nT in full scale field. It rotates as well the CSC sensor axes. In principle this is due to the presence of soft magnetic material. No remanent magnetization has been observed. Hermann Luehr has ratified this fact and recommended a final calibration in Magnetsrode with the final assembled flight gondola. This could not be done at IABG, whose absolute accurately is not sufficient for this final test. Final calibration parameters will be obtained in test with SIM mounted just before delivering for integration in the satellite. Among the runs we made, only one has been chosen for each combination. The residual graphs show typical outputs, any others look in the same way. Nevertheless, anyone is welcome to ask for any other output or graph. The graphs shown are: sensitivity change of the three axes, non-orthogonal angles and residuals vs. temperature in 2nd thermal run of the flight unit. The residuals show some outliers due to the mechanical perturbation while removing the dry ice. Due to the speed of temperature change the thermodynamic equilibrium is not well achieved in the cooling phase, and that gives a little bit dispersion of the parameters.