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Quality Assurance Project for the Magnetic Calibration and Test Laboratory of the Nurmijärvi Geophysical Observatory

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Abstract

The magnetic calibration and test laboratory of the Nurmijärvi Geophysical Observatory is aimed for magnetometer and compass calibrations, for magnetic cleanliness measurements and for compass swing base measurements at airfields. The increased importance of space and aviation industry has given rise to the development of the quality system for the calibrations and tests. The European standard EN ISO/IEC 17025:2000 states the demands for the quality system. This standard has been followed both for technical and management requirements. We will describe main technical parameters and competence of the laboratory. Traceability to the international standards is fulfilled and comparisons with other laboratories have been made.

1. General Information

Since its beginning in 1951, the Nurmijärvi Geophysical Observatory is part of the Finnish Meteorological Institute. During the first decades, the Geophysics Department of the institute had a remarkable science program in geomagnetism and the observatory had a key role in this study. Gradually the role of space physics increased in the department and in 2004 the name of department was changed to Space Research Division. Still today observation of the magnetic field variations over the whole of Finland is one of the corner stones of the Space Research Division. The Nurmijärvi observatory has searched for other activities to preserve also basic magnetic observations. In this respect the need of the society for magnetic observations and magnetic measurements has become important. These include declination information for maps, measurements at airfields and calibrations of sight compasses. Internationally, there has been a need for satellite and ground based magnetometer calibrations (Pajunpää *et al*. 1997) and magnetic cleanliness measurements for satellite components. Excluding the map declination measurements, the observatory has combined the calibrations and tests under the name “Nurmijärvi Magnetic Calibration and Test Laboratory” (NuMCTL).

A project was initiated at the end of 2003 to build a quality system for the laboratory and to get an accreditation for the facility. The aim of the project was to improve the reliability of the measurements and the quality of all functions. An application for the accreditation was given to the Finnish Accreditation Services (FINAS) in October 2006.

2. Building up the Quality System

The quality system was built for the NuMCTL in 2004-2005. The standard ISO/IEC 17025:2005 (CEN/CENELEC 2005) specifies the requirements for the competence to carry out tests and calibrations and was the basis for the work. A quality manual and method guides for all test and calibration methods were published. The work was guided by a steering committee that had meetings almost every month.

3. Traceability of the Measured Quantities

The measured quantities need to be traced to the international standard values (SI). In all the tests and calibrations the key values are the direction of the magnetic field and the scalar magnetic induction. Therefore, the standard magnetic observatory instruments, a DI-theodolite and a proton magnetometer, play a central role in the tracing of the measured quantities. In the magnetometer calibration the DI-theodolite is used to measure the magnetic directions in the calibration coil system, and the proton magnetometer is used to measure the coil constants. The DI-theodolite and the proton magnetometer are also used for magnetic anomaly and declination measurements on the airfields during compass swing base measurements and for absolute measurements in the absolute house of the observatory. The compass calibration is based on the known declination in the absolute house.

The traceability of the DI-theodolite is based purely on the comparison measurements at IAGA workshops and in the Nordic Comparison meetings. The proton magnetometer is also compared in the IAGA workshops but another calibration for the instrument is performed by a calibrated frequency standard. In the table below are the comparison results for the Zeiss Jena THEO 010B with a DMI fluxgate and for a PMP-7 proton precession magnetometer. The PMP-7 was here corrected for its old gyro constant. Table 1 shows the difference of the NuMCTL from the average result of the international observatory community. The calibrated 2 kHz frequency standard of the NuMCTL has given for the PMP-7 at constant temperature an error of less than ±0.1 nT during several years.

In the magnetometer calibration the electric current measurement is the essential parameter affecting the accuracy. However the absolute accuracy of the current is not important as it is taken care of in the coil constant determination. Critical is the stability of the current measurement. Therefore, the current measurement system based on three 1-ohm resistors is calibrated with an external reference resistor. Especially the temperature dependence of the resistors needs to be determined.

Table 1

Comparison results for the DI-theodolite and PMP-7 of the Nurmijärvi observatory

Workshop year	Dourbes 1994	Niemegk 1996	Hurbanovo 2000	Kakioka 2004	Uppsala 2005
Delta D	< 10″	< 5″	< 5″	< 10″	< 5″
Delta I	< 5″	< 5″	< 10″	< 5″	< 5″
F	< 0.5nT		< 0.2nT	< 0.2nT	

4. Estimation of Uncertainty

Estimation of the uncertainty of the measurements is based on the publication EA-4/02 of the European Co-operation for Accreditation (EAL Committee 2 1999). Standard uncertainties of all input quantities were estimated and an uncertainty budget

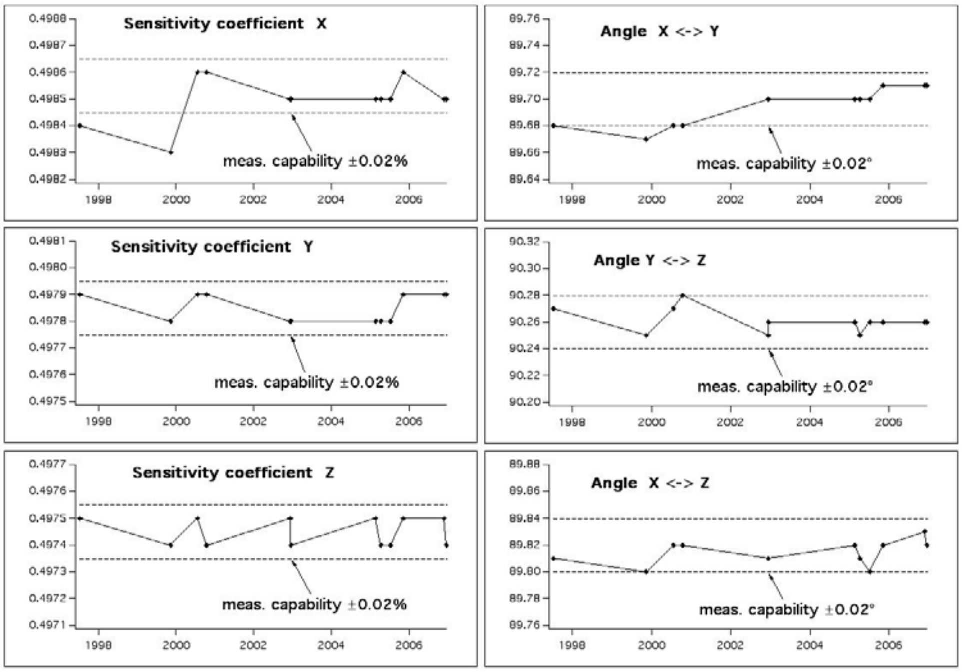

Fig. 1. Sensitivity coefficients (left) in the units [nT/mV] and angles between sensors (right) in the units [degrees] of the LEMI-004 magnetometer as determined with the calibration system during the years 1997-2006 (horizontal axis). The standard uncertainty limits are presented as the dashed lines.

was built for the calibration quantities. In Fig. 1 the standard uncertainty limits (dashed lines) are presented for the low noise LEMI-004 magnetometer (Korepanov *et al.* 1996). The aim of the picture is to present the combined stability of the magnetometer and of the calibration system.

5. Measurement Capability

In Table 2 we present the best measurement capability of the NuMCTL. These extended (coverage factor k = 2) standard uncertainty values were determined in the uncertainty estimation. The assigned values correspond to coverage probabilities of approximately 95%. In the case of magnetometer calibration, the uncertainty depends also on the calibrated magnetometer. The result of an instrument with poor resolution and accuracy is associated with larger numbers of uncertainty.

Table 2

Measurement capability with extended (k = 2) standard uncertainty

Magnetometer calibration	
Angles between orthogonal components of a magnetometer	±0.02°
Angles between magnetic and mechanical axes of a magnetometer	±0.03°
Transformation coefficients of a magnetometer	±0.02%
Offsets of a magnetometer	±1 nT
Temperature drift of a magnetometer	±0.03 nT/°C
Compass calibration	
Error of a sight compass	±0.5°
Magnetic cleanliness measurement	
Magnetic dipole moment	±5%
Direction of magnetic dipole	±5°
Centre of magnetic dipole	±5 cm
Compass swing base measurement	
Relative magnetic declination	±0.02°
Absolute magnetic declination	±0.03°

6. Discussion

The NuMCTL provides means and equipment for accurate calibration of three-component magnetometers for satellite and ground based observations. Sight compasses are calibrated for aviation companies and authorities and compass swing bases at airfields are explored for magnetic anomalies and determined for declination. Additionally the laboratory makes magnetic cleanliness measurements for satellite instruments.

A quality system has been built for the laboratory and an application for accreditation has been left for most part of NuMCTL activities.

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