SOFIA AIRPORT GEOMAGNETIC SURVEY

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Abstract Although the modern electronic devices are used as a primary direction indicators for aircrafts, magnetic compasses remain important back-up systems on airplanes. Airports infrastructure must include special sites which allow an aircraft check to be performed, and to calibrate onboard compasses. There are certain requirements towards those sites and the most important one is the geomagnetic declination homogeneity. The present paper describes methodology and results of the geomagnetic survey performed at the Sofia airport investigating the suitability of the north deicing pad to be used as a calibration site for aircraft compass systems. The total intensity of the geomagnetic field and geomagnetic declination were measured and analyzed. As a result, major magnetic disturbers were delineated and the suitable for compass calibration area was determined.

Key words: geomagnetic measurements, magnetic declination, compass calibration, Sofia airport compensation pad

Introduction

The use of a magnetic compass as a direction finder occurred sometime in the middle of the 11th century and was recorded in the Chinese literature. The typical Chinese navigational compass was in the form of a magnetic needle floating in a bowl of water. The principle function of the compass is to indicate the direction of the North magnetic pole called “magnetic north”. In navigation, directions on maps are expressed with reference to geographical or “true north”, the direction toward the Geographical North Pole. Since the Earth's magnetic poles are near, but are not at the same locations as its geographic poles, a compass does not point to true north. Magnetic declination varies both from place to place, and with the passage of time due to magnetic changes in the Earth's core. Modern (2005) magnetic pole is located near Ellesmere Island in northern Canada at 82.7°N 114.4°W and is moving to the east at about 60 km per year (www.nrcan.gc.ca). Depending on where the compass is located on the surface of the Earth the angle between true north and magnetic north, called magnetic declination can vary widely (Fig. 1).

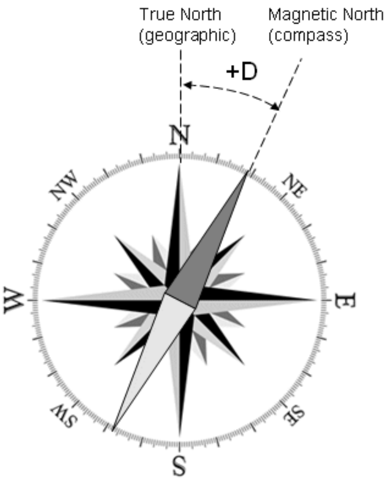

Fig. 1 An example of positive (east) declination when the compass is pointing clockwise with respect to the True North.

The local magnetic declination is given on most maps, to allow the map to be oriented with a compass parallel to true north. Furthermore, information about temporal and spatial changes of magnetic declination is given in specialized maps of geomagnetic declination (isogonal maps)..

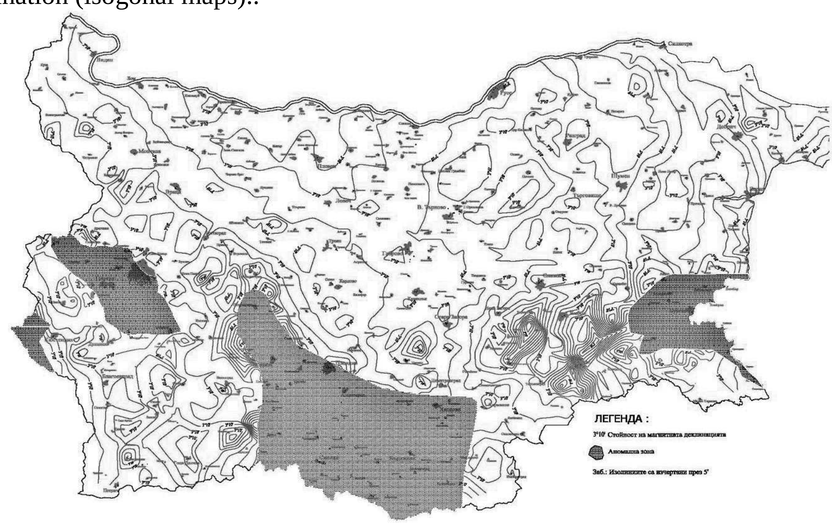

Fig. 2 Magnetic declination map of Bulgaria for the year 2006. Isolines are plotted in 5' interval. Anomalous zones are hatched

These maps are products provided by geomagnetic observatories all over the world. They are derived from declination measurements made at geomagnetic repeat stations and used for scientific research. An example of magnetic declination map of Bulgaria is given in Fig. 2.

Despite the presence of modern electronic devices aeronautics still needs of magnetic compasses as a primary direction indicators on small aircrafts and as very important back-up devices on larger airplanes. Airports infrastructure must include elements which allow an aircraft check to be performed, and to calibrate or compensate onboard compasses (Rasson, 2006). Main task of the present research was to determine the suitability of the north deicing pad of the Sofia airport to be used as a calibration site for backup compass systems of Airbus 320 and Boeing 737 airplanes.

Standby compass calibration procedure.

There are two types of procedures which can be used for calibration of the aircraft compass systems. First procedure needs to have a compass rose built on the calibration site. In that case, magnetic azimuth markings painted as radials every 30 degrees are applied to the calibration pad so that the aircraft can be precisely oriented along them performing a “compass swinging procedure”.

If there is no compass rose designed at the airport, corrections for the magnetic influence on the onboard magnetic field sensors can be done using an alternative swing procedure. It applies a standby compass calibration according to the readings of the primary electronic system of the aircraft (EHSI). During the adjustment procedure the airplane is turned subsequently to the north, east, south and west directions and differences between the magnetic headings of EHSI and the compass headings are recorded. Using these results, adjustment values are calculated and standby compass is corrected using non magnetic screwdriver. After the calibration procedure a compass correction card for the standby magnetic compass has to be prepared turning the airplane for each 30^{o} heading increment.

Technical requirements for compass calibration sites

Requirements for a compass calibration site are associated with the need to assure constant values of magnetic declination of the area and assess the impact of potential disturbants, represented by various objects affecting geomagnetic field (e.g. manholes, power poles, sewers, etc.).

The general requirements of the FAA for certification of the compensation pad area is 180 m distance from large magnetic objects such as buildings, roads and high-voltage equipment and locating small objects within a radius of 75 m from the center of the site (Berarducci, 2006).

According to the technical requirements of manufacturers of backup compass systems of the Airbus 320 and Boeing 737, named in compass compensation procedure’s description, the criterion for homogeneity of the magnetic declination over the site is a variation within $\pm 1^{o}$.

Methodology

GRID SETUP

North deicing pad of the Sofia airport (Fig. 3) was chosen as a calibration site on the base of primary investigations made in 2008. A rectangular measuring set 70x80 m in size with distance between points 10m has been placed using Leica Geosystems Total Station. Two permanent nearby located objects were used as geographic north azimuth markers for declination measurements.

Fig. 3. Location of the compass compensation site near the westward end of runway 1 of the Sofia airport (circled).

TOTAL FIELD SURVEY

The magnetic field total intensity values were measured with proton magnetometer GSM19 in each point of the grid. Four control measurements were performed in the center of the grid throughout measuring day in order to monitor changes in the field *in situ* and to evaluate apparatus stability. Acquired data were corrected for the diurnal geomagnetic field variation, using data from continuous registrations in PAG magnetic observatory. Total intensity variations of the compensation site area were plotted.

MAGNETIC DECLINATION SURVEY

The measurements of the North direction were performed with DI-Flux magnetometer in 9 points of the measuring grid, evenly spaced within the studied area. The fluxgate probe was attached to the telescope of a non-magnetic theodolite. The theodolite was centered and leveled over each measuring point. The measurements were performed in the four positions (Jankowski and Sucksdorf, 1996) with 3 readings in each position. The time of each measurement was noted using clock accurate to within one second. In each point two independent measurements were conducted by two different observers. A non-magnetic umbrella was employed to provide shadow for the instrument in order to maintain constant temperature during the measurements which is critical (due to expansion of leveling liquid and instrument). After measurements were completed, acquired data were processed, diurnal geomagnetic field variations were removed and declination values were calculated. Subsequently a map of the declination values was derived.

Results

VARIATIONS OF THE TOTAL INTENSITY VALUES

Magnetic field total intensity values measured within the area varies between 46495-48052 nT. That relatively large variation interval is caused by the presence of nearly placed objects disturbing the magnetic field in the area. Main disturbers are the drainage shafts, located near the east end of the site, and electrical facility near the north end. Total intensity values variation relative to central point (p. 41) is plotted on a map (Fig.4.).

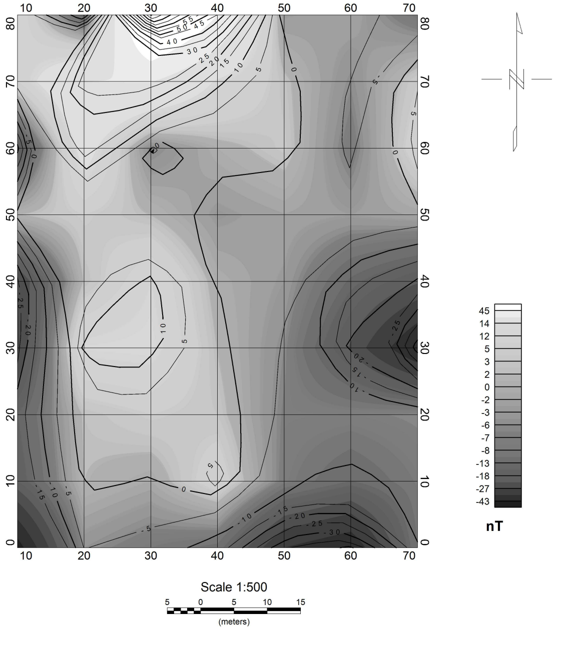

Fig. 4. Gradient of the total intensity of the geomagnetic field relative to the central point of the measuring grid.

It is seen on the map that the influence of the disturbing objects decreases rapidly moving away from them. This is a positive effect due to the small size of the objects.

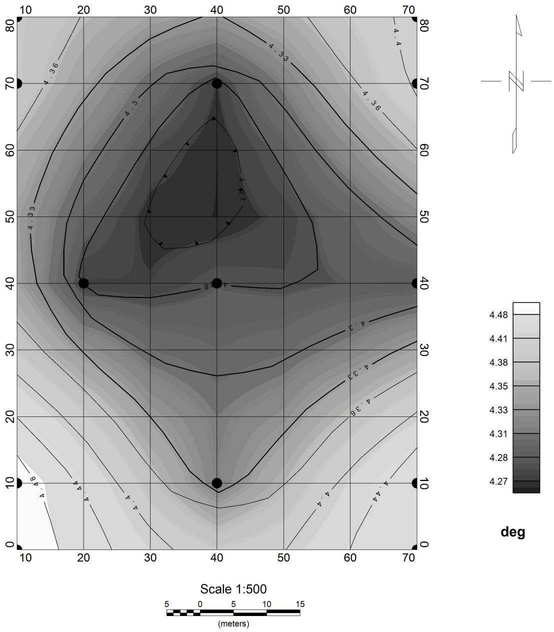

Fig. 5. Gradient of the magnetic declination relative to the central point of the measuring set without the effect caused by the shafts placed at the east end of the pad

VARIATIONS OF THE GEOMAGNETIC DECLINATION VALUES

Optimal number and location of measuring points at which declination needs to be measured was determined according to the results of total intensity values examination. Nine points (marked with red on the scheme of Fig. 7), evenly distributed around the central point were chosen. This allows us to determine the gradient of the declination in the four geographic directions. Results from our investigation showed that declination varies in the interval 4.26-4.51^{o}. Gradient of the declination over the territory of the pad is displayed in Fig. 5.

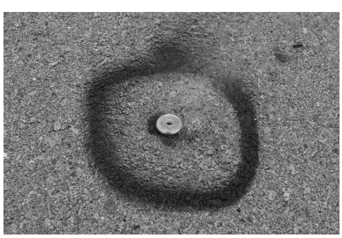

Fig. 6. Geomagnetic declination measurements and reference marks setup.

REFERENCE MARKS SETUP

According to the results obtained for the variations of the magnetic field total intensity values and geomagnetic declination over the pad area, position of three reference marks was determined and fixed by non-magnetic bolts (Fig. 6). These marks will be used as repeat stations for periodic measurements of the geomagnetic field components to quantify the change by means of secular variation and to update the declination values over the pad. The three permanent marks (p.14, p.39, p.41 in Fig 7) could be used as a landmark for aircraft positioning during calibrating procedures.

Conclusions

Results from the present research show that inside the pad area a homogeneous zone 50x70m in size is present, where magnetic field gradient is negligible (below 2 nT/m). Maximum deviation of the declination values is 0.25^{o} (15′) for the whole pad area in case there is at least 10 m distance from the shafts located at the east end of the site.

Consequently, the investigated area can be used as a compensation pad for backup compass system calibration.

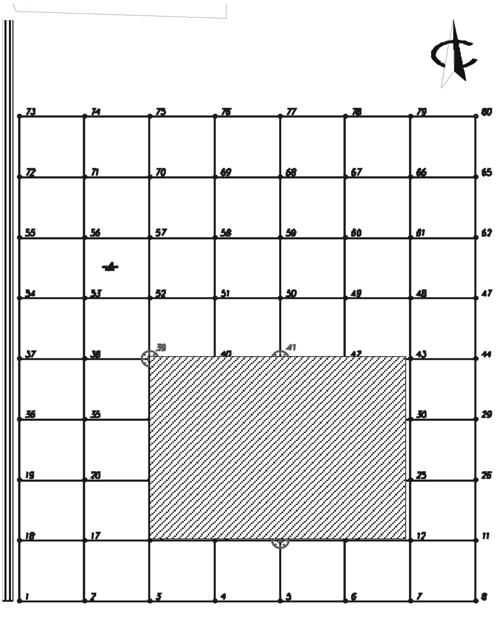

Fig. 7. Scheme of the placed measuring grid, reference point marks and outlined homogeneous zone suitable for performing compass compensation procedures

To avoid obstructive influence of the magnetic disturbers located nearby it was recommended to use the most homogeneous section of the pad located in the south-western part. Its position is marked by hatched rectangle 40x40 m in size on the scheme of Fig. 7.

Acknowledgements

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Геомагнитно проучване на летище София

П. Трифонова, М. Методиев, И. Чолаков, И. Радев

Резюме Въпреки широкото използване на съвременни електронни уреди в самолетната навигация, магнитните компаси остават важна част от резервните им системи за сигурност. Инфраструктурата на летищата трябва да разполага със специални площадки, позволяващи да бъде извършена настройка на самолетните компаси. Съществуват определени изисквания към подобен тип площадки, и най-важното от тях е хомогенност на магнитната деклинация. Настоящата работа описва методологията и резултатите от геомагнитно проучване, проведено на летище София за изследване на пригодността на северната противообледенителна площадка да бъде използвана за калибриране на компасните системи на самолети. Измерени и анализирани са големината на тоталния интензитет на геомагнитното поле и магнитната деклинация. В резултат на това са очертани основните магнитни смутители в района на площадката и е определена подходящата зона за извършване на калибрационни процедури.