INTRODUCTION TO THE ADVANCED RESEARCH WORKSHOP: "NEW MAGNETIC FIELD DATA IN THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA FOR ENHANCED FLYING AND AIRPORT SAFETY"

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1. Introduction

1.1. MACEDONIA, THE BALKANS AND SURROUNDINGS

The Republic of Macedonia, formerly part of Yugoslavia, has taken the initiative to call on the expertise of both scientific researchers in geomagnetism (modelers, cartographers, surveyors and, geophysicists) and aeronautical experts (pilots, aircraft operators, and airport managers) to improve aeronautical and airport safety.

This ARW will unite the two professional groups around a navigation instrument: the magnetic compass. During this workshop, we will review how the knowledge of geomagnetism and in particular magnetic declination, can be used to improve aeronautical safety.

The recent splitting up of Yugoslavia and subsequent political evolution of the Balkans, along with its rich scientific past (Nikola Tesla was born and lived here) contribute to the value of holding the workshop here.

1.2. MAGNETIC FIELD

The geomagnetic field is a vector quantity, and as such it is characterized either by its cartesian components X, Y and Z or by:

- two angles: declination, D, and inclination, I, expressed in degrees and
- an intensity, F (modulus or "Total Field"), expressed in nanoteslas.

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Magnetic observers strive to measure those quantities with an accuracy of one second of arc for D and I and one tenth of a nanotesla for F. This high accuracy is necessary to ensure correct extrapolations when forecasts are made, a procedure which tends to amplify the observation errors.

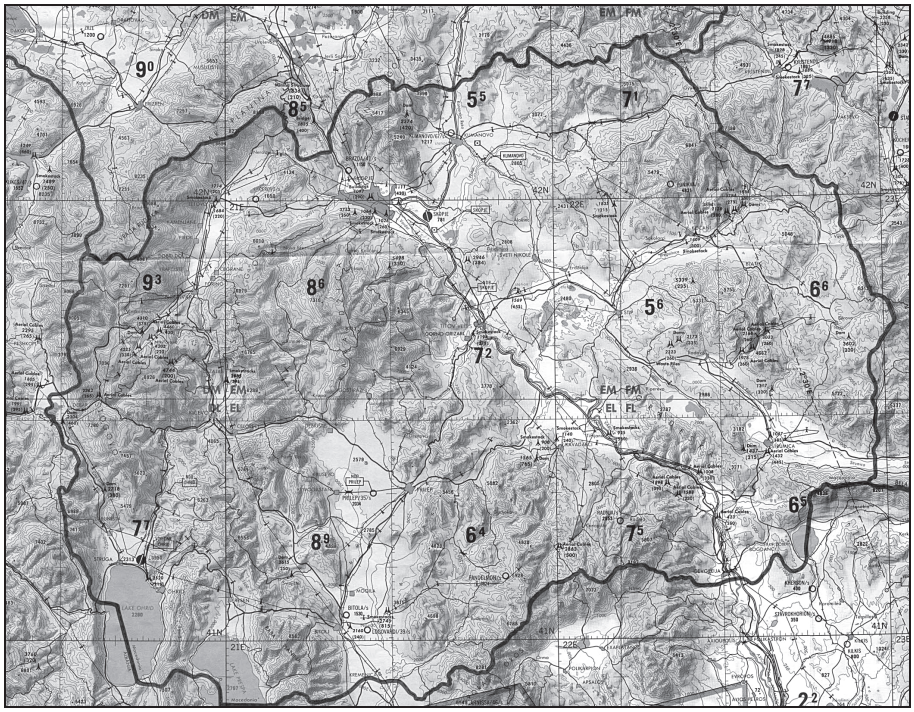

Figure 1. The Republic of Macedonia: an aeronautical map.

2. Aim of this ARW

The aim is to enhance the security in aircraft and airports throughout Macedonia, the Balkans, and the surrounding area.

How?

- By providing the correct value of the magnetic declination where and when it is needed:
    - o At the airports now
    - o At the airports in the future
    - o Over the Balkan region's airspace
- By ensuring that aircraft magnetic compasses are working properly
    - o Certify compass roses for the compass swinging procedure
    - o Calibrate aircraft compasses

3. Aeronautical conditions in Macedonia

Figure 1 is a map of the Republic of Macedonia showing airport locations, elevation, and other physical features. The very mountainous terrain creates a difficulty for aircraft. The two major international airports of Ohrid and Skopje are indicated as well as other small airports like the ones in Bitola and Ponikva .

When consulting the web-pages of the Macedonian airports, we looked for magnetic declination information. Skopje Airport did not give this data while the airport in Ohrid gave data which is 15 years old (obsolete) as seen in Figure 2.

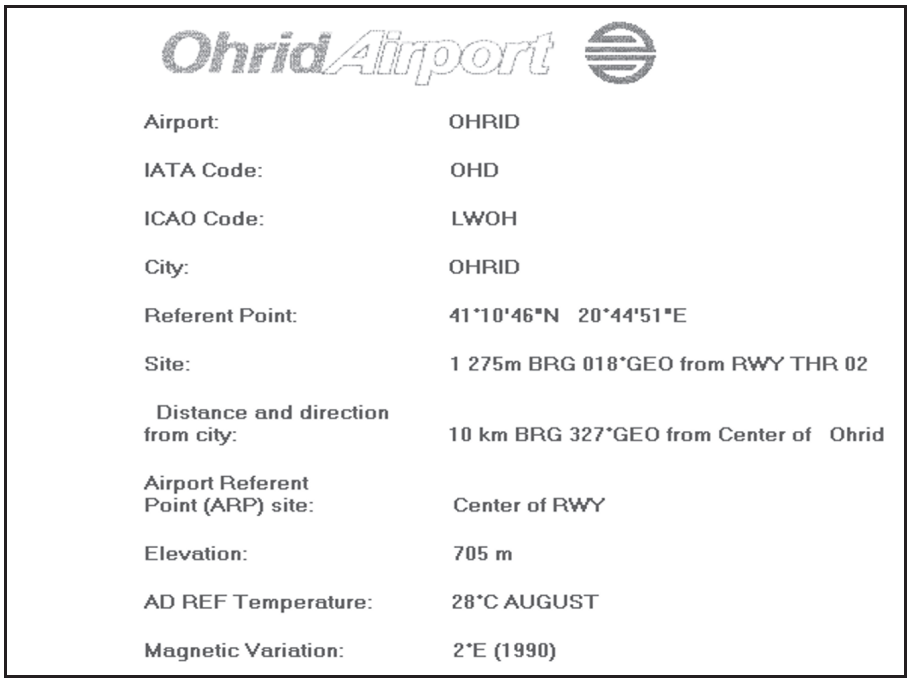

Figure 2. Extract from the web-page of Ohrid airport (2005).

Enhanced safety in aeronautics can be obtained by using up-to-date geomagnetic measurements. An integral part of this workshop is to point out the necessity of using correct and up to date geomagnetic data.

4. What are our assets?

4.1. PROTECTED SITES

The geomagnetic community has at hand a set of about 150 magnetic observatories in Europe and worldwide, where the geomagnetic field is measured on a continual basis, often at a rate of one full vector of the field at 1 sample per minute or faster. These sites are carefully protected from magnetic perturbations, so as to ensure that they observe the natural magnetic field and not one perturbed by cultural or technical noise. This is the same unperturbed field which will be measured by the compass of an aircraft flying aloft. Many of these observatories belong to the INTERMAGNET network, offering their data in near real-time on the INTERNET. Figure 3 shows a protected magnetic observatory site. Note that the observatory buildings are made exclusively of non-magnetic materials like wood, copper, white sandstone, and nonmagnetic concrete. It is worth mentioning here that the Republic of Macedonia is contemplating the construction of a magnetic observatory soon.

Figure 3. A protected site: the geomagnetic Observatory of Dourbes, Belgium.

4.2. TRAINED AND DEDICATED PEOPLE

Geomagneticians are available at observatories as well as at specialized geophysical, geological, meteorological, university, or topography institutes, to observe and measure the Earth's geomagnetic field over time as a time series or in space as spatial variations.

These professionals are very keen to work for the aeronautical sector. The application of geomagnetics to aeronautics extends work into the commercial realm. In the past, geomagnetic studies have been mostly academic.

4.3. AVAILABILITY OF GLOBAL AND REGIONAL MODELS

A sizeable part of the geomagnetic community is very busy with the modelling of the geomagnetic field. Measurements of the Earth's magnetic field are incorporated into regional and/or global models. Special mathematical techniques, used to distribute data on spherical surfaces are used. Thanks to these techniques, aircraft pilots have a clear idea of how geomagnetic declination behaves on the Earths Globe and know precisely how they must interpret the bearings given by their magnetic compasses.

4.4. KNOW-HOW

Accurate measurement of the geomagnetic field is not easy, especially at the sub-nanotesla and second of arc level. Additionally, measurement difficulty stems from the fact that only the natural field is to be measured. The observer must be magnetically clean. The observatory buildings and surrounding underlying terrain must be free from magnetic contaminants.

Up to now only trained geomagneticians had the expertise to make accurate measurements. Now, some topographical and military institutes are capable.

4.5. UP-TO-DATE AND VAST GEOMAGNETIC DATA BASES

Magnetic observatories have existed for more than 500 years. A huge database of geomagnetic observations has been accumulated in the so called "World Data Centres". They can be reached with the links given in Table 1.

Table 1. List of the Geomagnetic World data Centers.

LOCATION	URL or Email
KYOTO	http://swdcwww.kugi.kyoto-u.ac.jp/catmap/index.html
COPENHAGEN	http://web.dmi.dk/projects/wdcc1

LOCATION	URL or Email
EDINBURGH	http://www.geomag.bgs.ac.uk/gifs/on_line_gifs.html
MUMBAI	abh@iigs.iigm.res.in

Updates to the WDC's addresses can be found at http://www.ngdc.noaa.gov/wdc/list.shtml

Another database is offered by the INTERMAGNET consortium (www.intermagnet.org). INTERMAGNET provides high quality data at a sampling rate of 1minute and accessibility in near real time. This worldwide network presently offers data from about 100 magnetic observatories, as depicted on Figure 4.

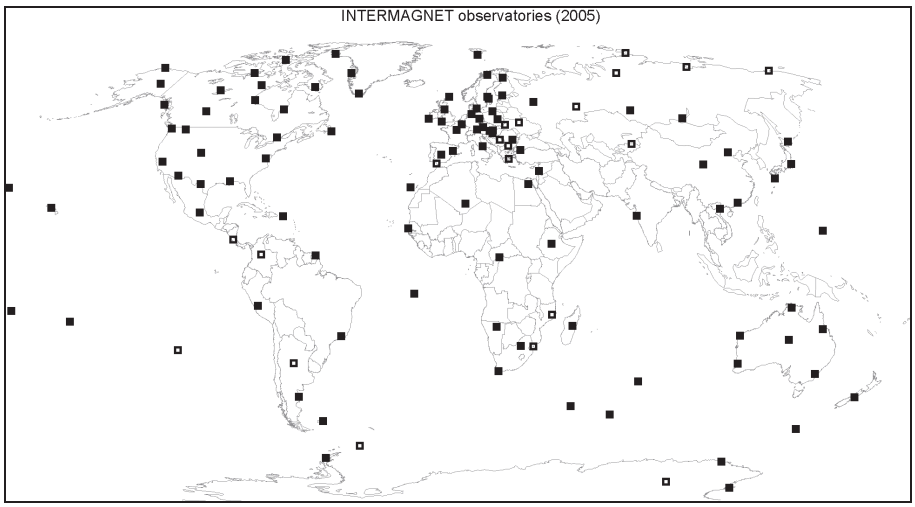

Figure 4. World map with the INTERMAGNET magnetic observatories as of 2005.

The timely availability of online or archived data is important for successful delivery of magnetic declination data to the aeronautical community.

4.6. QUASI MONOPOLY

Due to the specialized nature of the work, the costly infrastructure of geomagnetic observatories, and the relatively low demand from the commercial sector, one institution per country can provide geomagnetic information to interested parties. Therefore, a *de-facto* monopoly exists for the supply of these services and products. This is a favourable situation for those who intend to sell geomagnetic products and services.

5. How will this Workshop address its topics?

5.1. KNOW YOUR GEOLOGY

The local geology is of importance in an investigation of the geomagnetic features of a region. We will have a thorough review of the relevant geological features of Macedonia and of the Balkans in the paper by T Delipetrov. As Dean of the Faculty of Geology in Štip, Republic of Macedonia, he is one of the best informed scientists on the subject.

5.2. INVENTORY OF FIELD AND OBSERVATORY DATA

Among the participants of this Workshop there are key persons dealing with magnetic field measurements in the Balkans and surrounding areas. These scientists are going to show a detailed view of the geomagnetic data available for our purpose of compass navigation. Balkan countries, old and new and also the neighboring states have to get scientists together in order to rationalize and unify data, so that any discrepancies (at the borders for instance) can be normalized.

5.3. METROLOGY OF GEOMAGNETIC FIELD

Measuring the geomagnetic field depends very much on the availability of good instrumentation. Obtaining the required accuracy is a constant concern for the surveyor. Additionally, the reduction of staff observed during the last 20 years increasingly calls for faster measurements, protocols, and more user-friendly interfaces in order to carry on the ever increasing workload.

Therefore, advances in geomagnetic instrumentation frequently have to do with increasing the operator's comfort and reducing the operational tasks by taking advantage of automated procedures.

The methods for logging geomagnetic data in the observatory environment are not entirely satisfactory. We will have a few papers on how to make advances on that topic.

Finally, the geomagnetic community is a step closer to realizing its dream of having a fully automatic magnetic observatory operation as discussed in a paper on the automatic DIM.

5.4. SERVICES AND PRODUCTS FOR AERONAUTICS

A sizeable part of our workshop will be devoted to comparing methods used by the various attending experts. There has been a tendency toward

individualism in the past as each group performing services and measurements has been working in relative isolation.

This situation surely is not satisfactory, and the workshop will be a unique opportunity, offering a discussion forum where all our procedures and experiences can be evaluated by the geomagnetic community.

5.5. MATHEMATICAL PROCEDURES

Processing measurements into useable form is critical when creating products for the aeronautics sector. As the time of the actual measurements always precedes the publication of maps, values list, or spherical model, by about a year, there is a need to forecast the data. Customers like to have declination values which apply to the time interval they will be working in.

Sophisticated mathematical procedures can help greatly. We will have presentations on the Spherical Cap Harmonic Analysis technique applied to the computation of aeronautical maps, the Chaos theory will be put to use demonstrating how accurate forecasting of the geomagnetic field values can be achieved.