INTERMAGNET TECHNICAL REFERENCE MANUAL

Version 4.6
2012

Edited by: Benoît St-Louis

This document has been prepared by the INTERMAGNET Operations Committee and Executive Council. Every effort has been made to ensure that the information is accurate and current. The document is distributed in the hope that it will be a useful reference not only for those participating formally in INTERMAGNET, but also for the greater geomagnetic community.

Acknowledgements

We gratefully acknowledge the many and significant contributions and comments provided by our colleagues.

This manual is based on the original document (INTERMAGNET Technical Reference Manual version 1.0  1994 )

Edited by: Douglas F. Trigg
Richard L. Coles

Prepared by: Diane Regimbald

The INTERMAGNET office:

INTERMAGNET
c/o British Geological Survey
Murchison House
West Mains Road
Edinburgh EH9 3LA
UK
# TABLE OF CONTENTS

## QUICK REFERENCES
- INTERMAGNET WEB SITE ........................................................... v
- GIN INTERNET ADDRESSES ......................................................... v
- DVD/CD-ROM DISTRIBUTION OFFICE ........................................ v
- GENERAL INQUIRIES ............................................................... v

## CHAPTER 1 INTERMAGNET
1.1 INTRODUCTION .................................................................... 1
1.2 INTERMAGNET OBJECTIVE ..................................................... 1
1.3 HISTORY AND STATUS OF INTERMAGNET .............................. 1
1.4 THE INTERMAGNET PRINCIPLES AND CONDITIONS ................... 1
1.5 PARTICIPATION .................................................................... 2
1.6 PRODUCTS ........................................................................ 2
1.7 CONDITIONS OF USE ........................................................... 3
1.8 INTERMAGNET MANAGEMENT ............................................. 4

## CHAPTER 2 INTERMAGNET MAGNETIC OBSERVATORIES - IMOs
2.1 SPECIFICATIONS .................................................................. 5
2.2 DATA SAMPLING AND FILTERING ............................................. 5
2.3 DATA ENCODING FOR ELECTRONIC MAIL TRANSMISSION ............ 6
2.4 DATA ENCODING FOR SATELLITE TRANSMISSION ....................... 6
2.5 DATA ENCODING FOR DVD/CD-ROM ........................................ 6
2.6 ABSOLUTE MEASUREMENTS / BASELINES ................................. 6

## CHAPTER 3 GEOMAGNETIC INFORMATION NODES - GINs
3.1 DEFINITION ........................................................................ 9
3.2 FUNCTIONS AND RESPONSIBILITIES ........................................ 9
3.3 DATA TRANSMISSION FORMATS ............................................. 9
3.4 USER ACCESS TO GINs .......................................................... 10
3.5 GIN MANAGER ADDRESSES .................................................. 11
3.6 GIN INTERNET ADDRESSES .................................................. 11

## CHAPTER 4 THE INTERMAGNET DVD/CD-ROM
4.1 INTRODUCTION ................................................................... 13
4.2 GENERAL FEATURES ............................................................ 13
4.3 IAF INTERMAGNET ARCHIVE FORMAT (DVD/CD-ROM) ............... 13
  4.3.1 IAFV2.10 (2010 and after) ................................................. 13
  4.3.2 IAFV2.00 (2009) ............................................................ 14
  4.3.3 IAFV1.10 (2008) ............................................................ 15
  4.3.4 IAFV1.00 (2007 and before) ............................................... 15
4.4 STORAGE REQUIREMENTS ...................................................... 16
4.5 INTERMAGNET DVD/CD-ROM DIRECTORY STRUCTURE ............. 16
4.6 INTERMAGNET CD-ROM SOFTWARE ........................................ 17

## CHAPTER 5 SATELLITES
5.1 GEOSTATIONARY SATELLITES ................................................ 19
5.2 METEOSAT ......................................................................... 19
5.3 GOES ............................................................................... 19
5.4 TRANSMISSION ACCESS ...................................................... 19
5.5 SATELLITE OPERATORS ......................................................... 20
5.6 SATELLITE SERVICES ............................................................ 21
APPENDIX F-1
FILTER COEFFICIENTS TO PRODUCE ONE MINUTE VALUES ......................................... 77

APPENDIX G-1
INTERMAGNET MEMBERSHIP APPLICATION ................................................................. 79
INTERMAGNET MEMBERSHIP APPLICATION FORM ....................................................... 81
INTERMAGNET INSTRUMENT SPECIFICATION FORM ..................................................... 83
A. CONTINUOUSLY RECORDING VECTOR MAGNETOMETER ........................................ 83
B. CONTINUOUSLY RECORDING SCALAR MAGNETOMETER ...................................... 83
C. DATA ACQUISITION SYSTEM .................................................................................. 83
D. DATA TRANSMISSION ............................................................................................. 84
E. OBSERVATORY BASELINE INFORMATION ............................................................ 84
F. ABSOLUTE INSTRUMENTS ..................................................................................... 85
QUIK REFERENCES

- INTERMAGNET WEB SITE
  
  www.intermagnet.org

- GIN INTERNET ADDRESSES
  
  ottgin@geolab.nrcan.gc.ca
  par_gin@ipgp.fr
  gol_gin@ghtmail.cr.usgs.gov
  e_gin@mail.nmh.ac.uk
  kyoto-gin@swdcdb.kugi.kyoto-u.ac.jp

- DVD/CD-ROM DISTRIBUTION OFFICE
  
  INTERMAGNET DVD/CD-ROM distribution office
  Observatoire Magnétique National
  Carrefour des 8 routes
  F-45340 Chambon la Forêt
  FRANCE
  Tel:  33 (0) 2-38-33-95-00
  Fax:  33 (0) 2-38-33-95-04
  Internet:  imso@ipgp.fr

- GENERAL INQUIRIES
  
  Duff C. Stewart
  INTERMAGNET Operations Committee
  c/o U.S. Geological Survey
  Box 25046 MS 966
  Denver Federal Center
  Denver, Colorado 80225-0046
  USA

  TEL:  44-131-667-1000
  FAX:  44-131-667-1877
  INTERNET:  c.turbitt@bgs.ac.uk
CHAPTER 1 INTERMAGNET

1.1 INTRODUCTION

This manual describes the global near-real-time magnetic observatory network, known as INTERMAGNET. Throughout the document, the term "magnetic observatory" will mean a recording station where absolute measurements of the geomagnetic field are made on a regular basis over many years and which produces data of the requisite quality for secular variation studies. The term "near real-time" in this context means that data are supplied for distribution within 72 hours of acquisition.

The automation of magnetic observatories in several countries, operated remotely by means of telephone communications, has demonstrated that data on the dynamic magnetic field of the Earth can be collected quickly using modern data capture techniques and communications systems. It is logical to coordinate national activities and to extend the use of such techniques worldwide. It is now possible to adopt a new standard for geomagnetic measuring and monitoring equipment and to transfer data rapidly to regional Geomagnetic Information Nodes (GINs) using satellite and network communications. These geomagnetic information nodes collect data from their sector of the globe for dissemination to the user communities in a timely manner. GINs can, when needed, exchange data and may also disseminate products such as geomagnetic indices and activity models.

A successful pilot scheme operated during 1989, including the UK, USA, and Canada transmitting and receiving at 12 minute or 1 hour intervals geomagnetic data recorded every minute. As a result of the pilot scheme, the IAGA Executive Committee endorsed INTERMAGNET. The SEDI (Study of the Earth's Deep Interior) Steering Committee has also endorsed INTERMAGNET.

1.2 INTERMAGNET OBJECTIVE

The INTERMAGNET objective is to establish a global network of cooperating digital magnetic observatories, adopting modern standard specifications for measuring and recording equipment, in order to facilitate data exchange and the production of geomagnetic products in close to real time.

1.3 HISTORY AND STATUS OF INTERMAGNET

The possibility of worldwide data communication between magnetic observatories was first raised seriously at the Workshop on Magnetic Observatory Instruments, held in Ottawa, Canada, in August 1986. Further discussions, particularly between the British Geological Survey (BGS) and the US Geological Survey (USGS) took place in May 1987 at the Nordic Comparison Meeting held at Chambon la Forêt, France. A pilot scheme between BGS and USGS was described at the sessions of Division V of IAGA during the XIXth General Assembly of IUGG in Vancouver, Canada, in August 1987, with the proposal that the geomagnetic community should adopt automatic observatories with satellite communications as its mode of operation for the future. INTERMAGNET embodies the proposal to extend worldwide the network of observatories communicating in this way.

At present the observatories shown in Appendix B-1 are transmitting through satellites, or daily by computer link, to GINs. More stations are coming online rapidly. GINs are now operating in Edinburgh (BGS), Golden (USGS), Kyoto (Kyoto U.), Ottawa (GSC), and Paris (IPGP).

1.4 THE INTERMAGNET PRINCIPLES AND CONDITIONS

INTERMAGNET is operated according to principles and conditions which are accepted as necessary and desirable for maintaining a service of rapid magnetic observatory data exchanges for the international scientific community and for commercial users.

1. INTERMAGNET is a non-exclusive program of worldwide data exchange between magnetic observatories.
2. An INTERMAGNET aim is the establishment and maintenance of observatories in remote areas where local support is lacking.
3. INTERMAGNET encourages the establishment and maintenance of digital observatories in developing countries, with the involvement and enhancement of local science and technology.
4. Each participating country/institution is expected to bear the costs of its participation in INTERMAGNET.
5. Data will be transmitted from observatories or operating institutes to regional geomagnetic information nodes (GINs) by satellites, computer networks or by other near real-time means, using standard INTERMAGNET formats.

6. Regional geomagnetic information nodes will exchange data and data products globally as rapidly as appropriate, and will maintain data files for all contributing observatories for a period commensurate with the immediate usefulness of the product.

7. The collected data will be made available to the scientific community and to participating observatories on media and in formats approved by the INTERMAGNET Executive Council.

8. All data are supplied on the condition that they are not used for commercial gain (media, transcription and other costs may be charged to the user).

9. The INTERMAGNET Executive Council recognizes the value to commerce of geomagnetic data and derived products which are available in near real time, and accepts the right of participating institutions to recover costs for services and to levy charges where possible and as necessary. Participating institutions will undertake to safeguard the interests of fellow participants, concerning the commercial usage of their data.

10. Each INTERMAGNET GIN will provide annually to each participating institution or observatory a statement of data received by the GIN and of its data supplied by the GIN to users.

11. Participating institutes will co-operate to facilitate the production of globally representative data products, such as the official IAGA indices.

12. Participating institutions will agree to submit definitive data annually for inclusion on an INTERMAGNET DVD and will receive in return one copy of the DVD free of charge.

1.5 PARTICIPATION

INTERMAGNET membership is available to institutions who wish to operate one or more INTERMAGNET Magnetic Observatories (IMOs). Members agree to allow distribution of their IMO data in accordance with INTERMAGNET guidelines. In return for participation, Institutional membership provides: access to near real-time data from any IMOs for all members of the Institution; access to the best in magnetic observatory technologies and assistance in implementing them and possibilities of discounts on satellite communications. There are, at present, no membership fees. An application to become a member is submitted to the INTERMAGNET office for approval by the Executive Council, subject to technical evaluation by the Operations Committee. The membership application form is included in Appendix G-1.

Individual researchers may also be granted access to IMO data distributed through GINs. They must apply to an INTERMAGNET GIN and agree to abide by all INTERMAGNET guidelines. They will then be put in contact with the most convenient GIN. Charges for access to data may apply.

1.6 PRODUCTS

Minute values of geomagnetic components along with other INTERMAGNET products may be retrieved from the web site (http://www.intermagnet.org) under Data. Minute values are kept on-line permanently to allow comparisons between preliminary and definitive data and to give data sets that can be used to test software that works with preliminary data. When available, definitive data should preferably be used. A DVD (CD-ROM before 2006) containing definitive data from INTERMAGNET observatories is created annually. The INTERMAGNET DVDs/CD-ROMs are available at no charge to participating institutes and to bona fide scientists for academic purposes only. Technical help for operators of IMOs may also be available by special arrangements through the INTERMAGNET office.
1.7 CONDITIONS OF USE

The Geomagnetic data available through INTERMAGNET are provided for your use (and for the use of colleagues collaborating on the same project) and are not for sale or distribution by you to third parties, without the express written permission of the Institute that operates the observatory. Any report or publication that makes use of these data should acknowledge that Institute as the source. One copy of each report or publication should be sent to the Institute.

We ask that the data not be used for commercial purposes, nor in any project in which you, your organization, or your collaborators are in a commercial agreement with any third party.

Your e-mail address, which you provide to INTERMAGNET when requesting data, will be given to the Institute supplying the data so that it may monitor the use of its data.

By accessing these data you signify your acceptance of these terms and conditions. For commercial applications of observatory data, please contact the operating Institute directly.

INTERMAGNET accepts no liability in respect of loss, damage, injury or other occurrence arising from the provision of these data.
1.8 INTERMAGNET MANAGEMENT

The Executive Council establishes policy for INTERMAGNET, deals with questions of international participation and data exchange, and communicates with national agencies and international scientific and funding agencies.

Executive Council membership:

<table>
<thead>
<tr>
<th>Name</th>
<th>Country</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>J.J. Love</td>
<td>USA</td>
<td>(Chairman)</td>
</tr>
<tr>
<td>D. Boteler</td>
<td>Canada</td>
<td></td>
</tr>
<tr>
<td>A. Chulliat</td>
<td>France</td>
<td></td>
</tr>
<tr>
<td>D.J. Kerridge</td>
<td>UK</td>
<td></td>
</tr>
</tbody>
</table>

The Operations Committee advises the Executive Council on matters relating to magnetic sensors, data capture and data processing, and on communications options, protocols, etc. The Operations Committee is also responsible for establishing and maintaining standards of operation and uniform data formats and transmission characteristics which optimize global exchange.

Operations Committee membership:

<table>
<thead>
<tr>
<th>Name</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>C. Blais</td>
<td>Canada</td>
</tr>
<tr>
<td>P. Crosthwaite</td>
<td>Australia</td>
</tr>
<tr>
<td>S.M. Flower</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>H-J. Linthe</td>
<td>Germany</td>
</tr>
<tr>
<td>J. Matzka</td>
<td>Denmark</td>
</tr>
<tr>
<td>V. Maury</td>
<td>France</td>
</tr>
<tr>
<td>M. Nose</td>
<td>Japan</td>
</tr>
<tr>
<td>J. Rasson</td>
<td>Belgium (Chairman)</td>
</tr>
<tr>
<td>J. Reda</td>
<td>Poland</td>
</tr>
<tr>
<td>B.J. St-Louis</td>
<td>Canada</td>
</tr>
<tr>
<td>D.C. Stewart</td>
<td>USA</td>
</tr>
<tr>
<td>C.W. Turbitt</td>
<td>United Kingdom</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>J. Rasson</td>
<td></td>
</tr>
<tr>
<td>C. Turbitt</td>
<td></td>
</tr>
<tr>
<td>S. Flower</td>
<td></td>
</tr>
<tr>
<td>P. Crosthwaite</td>
<td></td>
</tr>
<tr>
<td>J. Matzka</td>
<td></td>
</tr>
<tr>
<td>M. Nose</td>
<td></td>
</tr>
<tr>
<td>D. St-Louis</td>
<td></td>
</tr>
<tr>
<td>H-J. Linthe</td>
<td></td>
</tr>
<tr>
<td>J. Reda</td>
<td></td>
</tr>
<tr>
<td>D. St-Louis</td>
<td></td>
</tr>
</tbody>
</table>

![INTERMAGNET Operations Committee](image)
CHAPTER 2  INTERMAGNET MAGNETIC OBSERVATORIES - IMOs

2.1 SPECIFICATIONS

An INTERMAGNET Magnetic Observatory (IMO) is a magnetic observatory, having full absolute control, that provides one minute magnetic field values measured by a vector magnetometer, and an optional scalar magnetometer, all with a resolution of 0.1 nT. Vector measurements performed by a magnetometer must include the best available baseline reference measurement.

An IMO must try to meet the following recommendations:

Definitive Data

Accuracy: ±5 nT

Absolute Measurements (See Section 2.6)

Vector Magnetometer

Resolution: 0.1 nT
Dynamic Range: 8000 nT High Latitude
6000 nT Mid/Equatorial Latitude
Band pass: D.C. to 0.1 Hz
Sampling rate: 1 Hz
Thermal stability: 0.25 nT/°C
Long term stability: 5 nT/year

Scalar Magnetometer

Resolution: 0.1 nT
Accuracy: 1 nT
Sampling rate: 0.033 Hz (30 sec)

Clock Timekeeping

Observatory data logger: 5 seconds/month
Data collection platform: ± 1.5 sec GOES, GMS
± 1.0 sec METEOSAT

Recorder

An on-site recorder is necessary so data are not lost as a result of satellite transmission outages.

Transmission

Transmission must be by satellite or other electronic means, within 72 hours of acquisition, to a Geomagnetic Information Node (GIN).

Note: Keeping within the time slot for satellite transmission is an important duty of an IMO operator. When advised by a GIN of a time drift, the IMO operator must make the necessary corrections within 24 hours.

Other

Data format: IAGA2002 or IMFV2.83 or IMFV1.23 (or later)
Definitive data: to be submitted for inclusion on the DVD/CD-ROM
Baseline data: each component to be submitted for inclusion on the DVD/CD-ROM
Filtering: to INTERMAGNET standard (Section 2.2)

Proton Gyromagnetic Ratio

In 2009, INTERMAGNET adopted the new proton gyromagnetic ratio published by the CODATA group in 2006: \( g_p = 2.675153362 \times 10^8 \text{ T}^{-1}\text{s}^{-1} \)

2.2 DATA SAMPLING AND FILTERING

In its Resolution 12 from the 1979 Assembly in Canberra, IAGA noted the desirability of digital magnetic observatories using a sampling rate no slower than once every 10 seconds. In that resolution, IAGA also stated that the one-minute means should be centered on the minute.

To minimize aliasing of higher frequency signals into the pass-band of the final minute data series, anti-aliasing filters should be included in the analogue portions of magnetometers before analogue-to-digital conversion. The filter responses should be matched to the chosen primary digital sampling rate. Subsequent to the digital sampling, INTERMAGNET requires that a numerical filter be applied in order to obtain the final minute data series.

One digital filter that is widely used by INTERMAGNET can be achieved by applying the following coefficients (for a Gaussian filter) to a series of 19 samples of 5-second data:

\[
\begin{align*}
C_0 &= 0.00229315 \\
C_1 &= 0.00531440 \\
C_2 &= 0.01115655 \\
C_3 &= 0.02121585 \\
C_4 &= 0.03654680 \\
C_5 &= 0.05702885 \\
C_6 &= 0.08061140 \\
C_7 &= 0.10321785 \\
C_8 &= 0.11972085 \\
C_9 &= 0.12578865 \\
C_{10} &= 0.11972085 \\
C_{11} &= 0.10321785 \\
C_{12} &= 0.08061140 \\
C_{13} &= 0.05702885 \\
C_{14} &= 0.03654680 \\
C_{15} &= 0.02121585 \\
C_{16} &= 0.01115655 \\
C_{17} &= 0.00531440 \\
C_{18} &= 0.00229315 \\
C_{19} &= 0.00023915
\end{align*}
\]
For a filter output value to be centered on the minute, coefficient \( C_0 \) is applied 45 seconds before this minute and coefficient \( C_{18} \) is applied 45 seconds after the minute.

In addition to the attenuation provided by the numerical filter, a “natural filter” applies, estimated at -9 to -18 dB/Octave typically, caused by the decrease in energy of the natural field with increasing frequency.

Examples of other acceptable sets of filter coefficients, for use with various sampling rates of properly anti-aliased signals are presented in Appendix F-1.

A scalar magnetometer must provide a sample centered on the same time as the output of the digital filter used with the vector magnetometer.

When mean values are to be calculated the question of how to handle missing data arises. For a number of reasons it is difficult to devise a simple objective rule that can be applied to all cases. INTERMAGNET recommends a simple and pragmatic approach; mean values may be calculated when 90% or more of the values required for calculation of the mean are available. When fewer than 90% of the required values are available the mean value should be assigned the value used to flag missing data. INTERMAGNET recommends adoption of this rule for both simple mean and weighted mean calculations. For example, a simple hourly mean value may be computed when 54 or more one-minute values are available for the hour. Similarly, if a one-minute value is constructed from one-second samples, the one-minute value may be computed when 54 or more one-second samples are available. In this case the weights (filter coefficients) assigned to the samples must be re-normalized (the sum of the weights applied to the samples used to calculate the mean value must be unity). INTERMAGNET observatories are expected to provide high levels of data continuity, so this rule is expected to be applied only rarely.

2.3 DATA ENCODING FOR ELECTRONIC MAIL TRANSMISSION

Electronic mail transmission of data to a GIN must be done using IAGA 2002 Format or INTERMAGNET GIN Dissemination Format for Minute Values IMFV1.23 described in Appendix E-3. When an IAGA 2002 file is sent, the SUBJECT field should contain the correctly formatted IAGA 2002 file name. When using the IMFV1.23 Format, the SUBJECT field of the electronic mail header should contain the filename being sent as defined in IMFV1.23.

for example:

Subject:MAR1592.BOU

This indicates that a day file containing data from Boulder observatory March 15 is sent. A complete day’s data is assembled into each IMFV1.23 file.

A list of GIN Internet addresses can be found in the Quick References section.

2.4 DATA ENCODING FOR SATELLITE TRANSMISSION

In preparation for transmitting data to one of several possible satellites an IMO will first prepare its data in INTERMAGNET format IMFV2.83 or later, which is fully described in Appendix E-1. This format imposes a common structure on the data files, ensuring that all necessary information is included so that the data may be properly decoded at a GIN. Once data are in IMFV2.83, a supplementary encoding step is applied to make the data stream, as transmitted to satellites, exactly compatible with the requirements of the satellite operators. Appendix E-2 shows the supplementary encoding steps for the GOES and Meteosat satellites along with examples using a specific data set. Appendix E-2 also provides provisional information about encoding for the GMS satellite.

2.5 DATA ENCODING FOR DVD/CD-ROM

Definitive data for an IMO are to be provided to INTERMAGNET shortly after the end of each calendar year (six months maximum) for inclusion in an annual INTERMAGNET DVD. The format for submission of data appears in Appendix C-1. Baseline data will accompany the definitive data, and will be provided in format IBFV2.00 or later as described in Appendix E-4. Refer to chapter 4 for a general description of the DVD/CD-ROM.

2.6 ABSOLUTE MEASUREMENTS / BASELINES

The provision of absolute control at a magnetic observatory requires a series of measurements of the absolute values of the geomagnetic field using manually operated instruments. Ideally, the frequency at which these measurements are made may vary from daily to weekly, depending on the variometer characteristics, the stability of the piers and installation and logistical considerations. The quality of the absolute control may be judged by examining the baseline corrections to the variometer data (see Appendix E-4). Some IMOs may use intermediate Reference Measurements (RM) which are more stable for inter-comparison. Chapter 6
provides a discussion of data quality control.

Several combinations of instrumentation are in use for absolute determinations, but INTERMAGNET recommends a proton precession magnetometer and a Declination/Inclination magnetometer (fluxgate mounted on a theodolite). Many factors are involved in achieving good baselines at a magnetic observatory. Some suggestions are presented in this short summary. A good adopted baseline shows a low scatter of individual baseline determinations, and has few drifts or offsets. Executive Council and Operations Committee recommend to:

1. Make weekly absolute observations, avoiding intervals of magnetic disturbance. If the baseline is changing rapidly, increase the frequency of absolute observations.

2. Make regular physical inspections of all observatory buildings to ensure that no magnetic materials which would cause jumps in baselines have been lying around, inside or outside the building.

3. Ensure that absolute instruments and their supporting piers are free from contaminating magnetic materials.

4. Set up a pier in an undisturbed area outside the absolute building; determine the absolute differences between the external pier and the main absolute pier at least once a year, to check for changes in the magnetic environment.

5. Maintain an up-to-date diary of absolute measurements, visits, repairs and other actions at the observatory.

6. Operate two variometers at the observatory and compare their data records.

7. Keep variometers, interconnecting cables, and control electronics at constant temperatures.

8. Continuously monitor and record the temperatures of all sensors, cables, and electronics units.

9. Review the procedures in use for absolute measurements at the observatory and consider if there are better procedures that could be use. INTERMAGNET recommends the use of a proton precession magnetometer and a Declination/Inclination magnetometer (fluxgate mounted on a theodolite).

10. Undertake visits between institutions by observers to encourage the exchange of ideas on instrumentation and observatory practice. Attend IAGA workshops.

11. Establish inter-observatory absolute instrument comparisons by observers, similar to the concept of the Scandinavian inter-observatory comparisons. Attend IAGA workshops.

12. Undertake better training of observers.

13. Provide meaningful information to observers about how their work contributes to local and worldwide research projects, and how baseline quality can affect the research.

This manual will not elaborate on the details of absolute techniques. However, useful articles can be found in Wienert (1970), Stuart (1984), Coles (1988), Kauristie et al. (1990), Rasson (1996), and Best and Linthe (1998). Two comprehensive manuals contain detailed sections on absolute measurement techniques. These are the "Guide for Magnetic Repeat Station Surveys" (Newitt, Barton, and Bitterly) and the "Guide for Magnetic Measurements and Observatory Practice" (Jankowski and Sucksdorff).

References:


CHAPTER 3 GEOMAGNETIC INFORMATION NODES - GINs

3.1 DEFINITION

In order that all INTERMAGNET data transfers may be handled efficiently, INTERMAGNET has established a number of Geomagnetic Information Nodes (GINs). The function of the GINs is to collect magnetic observatory data in near-real time, store it in a database, and forward it to the INTERMAGNET data repository from which it may be easily obtained through the web site by users of INTERMAGNET data. The GIN manager functions as a point of contact for IMOs to resolve any data transmission and formatting problems.

Geomagnetic Information Nodes have been set up in the following locations:

- Golden, Colorado - United States Geological Survey
- Ottawa, Canada - Geological Survey of Canada
- Edinburgh, Scotland - British Geological Survey
- Paris, France - Institut de Physique du Globe de Paris
- Kyoto, Japan - Kyoto University

Full GIN addresses are given at the end of this chapter. All sites are either equipped with satellite receiving equipment or receive satellite data from a satellite collecting center. All sites also have computers supporting electronic mail. This allows easy input of data from any magnetic observatory participating in INTERMAGNET. Depending on GIN location and the method used to input data, either satellite or electronic mail, observatory data are available to users from a minimum time of 12 minutes to a maximum time of 72 hours after the observatory recordings are made. If the observatory is transmitting its data through the GOES satellite links, the data reach the GIN within 12 minutes of recording. An alternative method, for observatories not equipped with satellite transmission equipment, is to input data to a GIN using electronic mail (E-Mail). To use this method an observatory must relay its data at least once every 72 hours to a GIN.

3.2 FUNCTIONS AND RESPONSIBILITIES

When observatory data are relayed to a GIN the format of these data may be either IAGA 2002, INTERMAGNET Format IMFV2.83 or INTERMAGNET GIN Dissemination Format for Minute Values IMFV1.23, or subsequent versions. The IMFV2.83 format is used for data transmitted through a satellite link, the IAGA 2002 and IMFV1.23 format for data input via an E-Mail message.

Once the data have been received the first process carried out by the GIN is to convert the IMFV2.83 format data to IMF V1.23 format and to designate them as REPORTED data. The second process is to forward these data files onto the INTERMAGNET data repository.

Each GIN will, as a routine daily task, produce stackplots of data received from all input sources. These are used as a quality assurance guide on the operation of each contributing observatory. No attempt will be made at any GIN to modify any REPORTED data input to it, but a GIN may apply spike removal routines to REPORTED data to produce other files from which stackplots are produced.

IMFV1.23 data can exist in one of three forms:

1) REPORTED Data - Data as input from an observatory, transmitting through a satellite or using E-Mail. REPORTED data have not had any baseline corrections applied, they may contain spikes and may have missing values.

2) ADJUSTED Data - Each observatory or its parent institute is allowed to modify REPORTED data files to produce ADJUSTED data, with a goal of 7 days after transmission. These adjustments may be to modify baselines, remove spikes or fill gaps, etc. on any day file. When data are missing from an ADJUSTED data file, these data may be input to a GIN in a later message. This new message file can be transmitted to a GIN with the 'A' flag set in byte 25 of each hourly block header. ADJUSTED data are maintained online until the annual DVD is available. They are then archived by the GIN and are only available thereafter by special arrangement.

3) DEFINITIVE Data - This describes observatory data which have been corrected for baseline variations, have had spikes removed and gaps filled where possible. DEFINITIVE data have each block header byte 25 in format IMFV1.23 set to 'D', and the quality of the data is such that in this form they would be used for inclusion into Observatory Year Books, input to World Data Centers and included on the annual INTERMAGNET DVD.

3.3 DATA TRANSMISSION FORMATS

In order that all INTERMAGNET data relayed between GINs and participating institutes share common standards, a series of GIN data formats have been
developed by the INTERMAGNET Operations Committee. All data transfers between GINs and IMOs are in these formats, and a GIN will not accept data from any INTERMAGNET participant unless they adhere strictly to the defined formats.

1) IAGA 2002 or IMFV1.23 INTERMAGNET GIN DISSEMINATION FORMAT FOR MINUTE VALUES

These define the formats in which observatory minute data may be input to a GIN by electronic mail. These formats are fully defined and described in Appendix E-3 and Appendix E-5.

2) INTERMAGNET GIN FORMAT FOR MAGNETIC INDICES

Details of this format have yet to be formulated by the INTERMAGNET Operations Committee. An addendum to this manual will be prepared when this format has been defined.

3.4 USER ACCESS TO GINs

GINs are responsible for data from the observatories listed in Appendix B-2. User access to the GINs is limited to the observatories who send their data to a given GIN. The access method is established separately by each GIN.

The complete INTERMAGNET data set for all participating observatories is very large. The entire database is located on the primary INTERMAGNET web server.

Public access to INTERMAGNET data is provided through the INTERMAGNET web site only. See Chapter 7 for more information on INTERMAGNET's web sites and data.
3.5 GIN MANAGER ADDRESSES

Any enquiries to individual GINs should be made to the INTERMAGNET GIN Manager at the following addresses:

USGS - USA:
Duff C. Stewart
U.S. Geological Survey
Box 25046 MS 966
Denver Federal Center
Denver, Colorado 80225-0046
USA
Telephone: 1-303-273-8485
Fax: 1-303-273-8506
Internet: gol_manager@ghtmail.cr.usgs.gov

GSC - Canada:
David Calp
Geological Survey of Canada
Geophysics Division
7 Observatory Crescent
Ottawa, Ontario
CANADA
K1A 0Y3
Telephone: 1-613-837-1757
Fax: 1-613-824-9803
Internet: ottmanager@geolab.nrcan.gc.ca

BGS - Scotland:
Simon M. Flower
Geomagnetism Team
British Geological Survey
Murchison House
West Mains Road
Edinburgh EH9 3LA
UK
Telephone: 44-131-667-1000
Fax: 44-131-667-1877
Internet: e_ginman@mail.nmh.ac.uk

IPG - France:
Virginie Maury
Institut de Physique du Globe de Paris
Observatoires magnétiques - Bureau 110
1, rue Jussieu
75238 Paris Cedex 05
FRANCE
Telephone: 33 (0) 1-83-95-77-80
Fax: 33 (0) 1-71-93-77-09
Internet: p_ginman@ipgp.fr

Kyoto University - Japan:
Masahito Nosé
Data Analysis Center for Geomagnetism and Space Magnetism
Graduate School of Science, Bldg #4
Kyoto University
Oiwake-cho, Kitashirakawa, Sakyoku
Kyoto 606-8502
JAPAN
Telephone: 81-75-753-3959
Fax: 81-75-722-7884
Internet: imagmanager@swdcdb.kugi.kyoto-u.ac.jp

3.6 GIN INTERNET ADDRESSES

ottgin@geolab.nrcan.gc.ca
par_gin@ipgp.fr
gol_gin@ghtmail.cr.usgs.gov
e_gin@mail.nmh.ac.uk
kyoto-gin@swdcdb.kugi.kyoto-u.ac.jp
CHAPTER 4   THE INTERMAGNET DVD/CD-ROM

4.1 INTRODUCTION

In January 1992 the Executive Council and Operations Committee decided to produce a CD-ROM of definitive minute data values from observatories of participating institutions, beginning with 1991 data and continuing annually thereafter. Users thus have access to global magnetic observatory data near-real time values and also the final, definitive data. Within six months after the end of the year the institution responsible for an IMO must deliver a complete set of definitive data (after de-spiking, padding of missing values, application of corrected baselines and other processing procedures) and samples of baseline data to be included on the annual INTERMAGNET DVD/CD-ROM.

The INTERMAGNET DVD/CD-ROM only contains data from participating observatories. Participating observatories are those that meet the INTERMAGNET standards and also report their data to a GIN within 72 hours of recording. The data from all contributing observatories were provided by the institutions responsible for those observatories.

4.2 GENERAL FEATURES

The first INTERMAGNET CD-ROM contains data from 41 observatories provided by 11 countries for the year 1991. These countries are Australia, Canada, Denmark, Finland, France, Hungary, Japan, Russia, Sweden, the United Kingdom, and the United States. The 1992 and later DVD/CD-ROMs also contain baseline data for the year for each observatory in the form of text and plots. Appendix B-1 of this manual provides a list of observatories currently contributing to the DVD, and Appendix B-2 gives a map showing their locations.

The DVD/CD-ROM itself conforms to the ISO 9660 standards, and only requires a DVD/CD-ROM reader with drive extensions that meet these standards to be operational. However, the access software (see below) requires several basic items, which include:
1. An IBM PC/AT or compatible microcomputer.
2. 640 Kilobytes (Kb) of memory.
3. MS-DOS or PC-DOS, version 3.1 or higher operating system.
4. Video Graphics Adapter (VGA) with at least 256 Kb of graphics memory.
5. An optional Epson-compatible dot matrix, or Hewlett-Packard Laserjet-compatible laser printer.

4.3 IAF INTERMAGNET ARCHIVE FORMAT (DVD/CD-ROM)

INTERMAGNET has published CDs and DVDs of geomagnetic observatory data since 1991. The CDs and DVDs contain a variety of metadata, including contact information and quality control records. The geomagnetic data on the CDs and DVDs is held in INTERMAGNET archive format. This format holds minute, hourly and daily mean values as well as K indices.

The data are coded as 32-bit (long integer) binary words, with 5888 words comprising a day-long record. Each file contains one month of day-records (so files are variable length, from 28 to 31 records). Each day of data has a header and data section, the data being subdivided into minute means, hourly means, daily means and a set of K-indices. To date, four versions of this format have been used: IAFV1.00 being the original description of the format. It was only designated as version 1.00 in 2007. Minor undocumented changes were made to how the header was used over the lifetime of this version. IAFV1.10 was defined in 2008 to add the publication date, encoding of the format version number and to reserve word 16 in the header, affecting words 14, 15 and 16. In 2009, delta-F was introduced in IAFV2.00 affecting words 6,8 and 15 in the header, and words 4337 to 5776, words 5849 to 5872 and word 5876 in the data section. Also in IAFV2.00, space padding was specified to be at the left most position affecting word 13 in the header and words 5885 to 5888 in the data section. In 2010, IAFV2.10 was defined to allow for a missing instrument designator affecting words 6 and 15 in the header, and words 4337 to 5776 in the data section. Appendix C-1 provides a schematic representation of the record structure.

4.3.1 IAFV2.10 (2010 and after)

Words 1 to 16 comprise the header section containing a mixture of text and numeric fields, including a 3-letter observatory identification preceded with a space [hex20] (ID) code, the year concatenated with the day of the year, co-latitude, longitude, elevation, reported orientation, originating organization, a D-conversion factor, data quality, instrumentation, K-9, sampling rate, sensor orientation, publication date and format version. From 2010 onward, the orientation codes "XYZ" and "HDZ" have been added to "XYZG" and "HDZG" where "G" represents ΔF (see description below). These new codes indicate that the observatory is recording 3
elements only (no scalar instrument). The D-conversion factor is a fixed value used only in the graphics portion of the access software to allow Declination to be plotted in minutes of arc and equivalent nanoteslas (nT). It is given as H/3438*10000, where H is the annual mean value of the horizontal intensity. Example: If H is 16500 D will be 47993(Integer). When XYZG or XYZ is used, the D-conversion factor should be set to 10000.

ASCII values, such as the observatory ID and orientation, are also stored as 32-bit words, but are coded as the hexadecimal byte-string corresponding to the ASCII string. For example, the string "HDZF" is coded as the sequence "48 44 5A 46". Where a string is shorter than four bytes, it is padded to the left with spaces. For example, the string "ESK" is coded as the sequence "20 45 53 4B".

Word 11 is the K-9 value for the observatory in nT, word 12 is the digital sampling rate in msec, and word 13 is the sensor orientation. Sensor orientation could be XYZF, DIF, UVZ, HDZ, HDZF etc. and should indicates which components are actually measured. If a three component sensor orientation is used, a space must be added to the left. Word 14 is the publication date encoded as 4 ASCII bytes "YYYY" provided by INTERMAGNET. The high byte (left most) of word 15 is the INTERMAGNET Archive Format version number code provided by the IMO. It takes the form of a binary single byte number ranging from 0 to 255. Zero (0x00) represents version 1.00, one (0x01) represents version 1.10, two (0x02) represents version 2.00 and three (0x03) represents version 2.10. The other three bytes of word 15 are reserved for future use and padded with zeros. Word 16 is reserved for future use.

Words 17-5776 contain the minute values of the 4 geomagnetic elements (successively X,Y,Z,G or H,D,Z,G or X,Y,Z, or H,D,Z ) for the day. From 2009 onward, the 4th element contains the difference between the square root of the sum of the squares of the variometer components, F(v), and the total field from an independent scalar recording, F(s). This difference, AF, is defined as F(v) - F(s). Both F(v) and F(s) must be corrected to the location in the observatory where absolute geomagnetic observations are made. When F(s) is missing or both F(s) and F(v) are missing, AF must be set to 999999. When F(v) only is missing, AF must be set to -F(s). The values of the 4 elements are stored in tenth-units with an implied decimal point. Thus, an H value of 21305.6 is stored (in tenth-nT) as 213056 with a decimal point implied between the last and next-to-last digits. Words 5777-5872 are used for the hourly mean values of the successive 4 elements. From 2009 onward, words 5849-5872 always record 999999 (missing value) because the quality check for daily means is also meaningless. From 2009 onward, the last 4 words (5885-5888) are available for each contributing institution. Missing data for minute, hour, and day values are stored as "999999". From 2010 onward, if a scalar instrument is not used (so no data is recorded in the fourth element) the value "888888" should be used instead of "999999". Missing K-Index values are stored as "999".

4.3.2 IAFV2.00 (2009)

Words 1 to 16 comprise the header section containing a mixture of text and numeric fields, including a 3-letter observatory identification preceded with a space [hex20] (ID) code, the year concatenated with the day of the year, co-latitude, longitude, elevation, reported orientation, originating organization, a D-conversion factor, data quality, instrumentation, K-9, sampling rate, sensor orientation, publication date and format version. From 2009 onward, the orientation must be "XYZG" or "HDZG" where "G" represents AF (see description below). The D-conversion factor is a fixed value used only in the graphics portion of the access software to allow Declination to be plotted in minutes of arc and equivalent nanoteslas (nT). It is given as H/3438*10000, where H is the annual mean value of the horizontal intensity. Example: If H is 16500 D will be 47993(Integer). When XYZG is used, the D-conversion factor should be set to 10000.

ASCII values, such as the observatory ID and orientation, are also stored as 32-bit words, but are coded as the hexadecimal byte-string provided by INTERMAGNET. The high byte (left most) of word 15 is the INTERMAGNET Archive Format version number code provided by the IMO. It takes the form of a binary single byte number ranging from 0 to 255. Zero (0x00) represents version 1.00, one (0x01) represents version 1.10, two (0x02) represents version 2.00 and three (0x03) represents version 2.10. The other three bytes of word 15 are reserved for future use and padded with zeros. Word 16 is reserved for future use and padded with zeros. Word 16 is reserved for future use.
future use.

Words 17-5776 contain the minute values of the 4 geomagnetic elements (successively X,Y,Z,G or H,D,Z,G) for the day. From 2009 onward, the 4th element contains the difference between the square root of the sum of the squares of the variometer components, F(v), and the total field from an independent scalar recording, F(s). This difference, ∆F, is defined as F(v) - F(s). Both F(v) and F(s) must be corrected to the location recording, F(s). This difference, ∆F, and the total field from an independent scalar element contains the difference between the square root of the sum of the squares of the variometer components, H,D,Z,G) for the day. From 2009 onward, the 4th element in the data is a quality check for the day. The 4th component "F" should be included only if it is measured from a scalar instrument independent of the other 3 components otherwise it must be filled with 999999. The values of the 4 components are stored in tenth-units with an implied decimal point. Thus, an H value of 21305.6 is stored (in tenth-nT) as 213056 with a decimal point implied between the last and next-to-last digits. Words 5777-5872 are used for the hourly mean values of the successive 4 elements. From 2009 onward, words 5849-5872 always record 999999 (missing value), this is done because the 4th element in the data is a quality check for minute mean data and this quality check is meaningless for hourly means. Words 5873-5876 store the 4 daily mean values. From 2009 onward, word 5876 always record 999999 (missing value) because the quality check for daily means is also meaningless. From 2009 onward, the last 4 words (5885-5888) are available for each contributing institution. Missing data for minute, hour, and day values are stored as "999999". Missing K-Index values are stored as "999".

4.3.3 IAFV1.10 (2008)

Words 1 to 16 comprise the header section containing a mixture of text and numeric fields, including a 3-letter observatory identification preceded with a space [hex20] (ID) code, the year concatenated with the day of the year, co-latitude, longitude, elevation, reported orientation, originating organization, a D-conversion factor, data quality, instrumentation, K-9, sampling rate, sensor orientation, publication date and format version. The orientation must be "XYZF" or "HDZF". If the F element is not measured, it must be filled with 999999 in the data section. The D-conversion factor is a fixed value used only in the graphics portion of the access software to allow Declination to be plotted in minutes of arc and equivalent nanoteslas (nT). It is given as H/3438*10000, where H is the annual mean value of the horizontal intensity. Example: If H is 16500 D will be 47993(Integer). When XYZF is used, the D-conversion factor should be set to 10000.

ASCII values, such as the observatory ID and orientation, are also stored as 32-bit words, but are coded as the hexadecimal byte-string corresponding to the ASCII string. For example, the string "HDZF" is coded as the sequence "48 44 5A 46".

Word 11 is the K-9 value for the observatory in nT, word 12 is the digital sampling rate in msec, and word 13 is the sensor orientation. Sensor orientation could be XYZF, DIF, UVZ, HDZ, HDZF etc. and should indicate which components are actually measured. If a three component sensor orientation is used, a space must be added at the end. Word 14 is the publication date encoded as 4 ASCII bytes "YYMM" provided by INTERMAGNET. The high byte (left most) of word 15 is the INTERMAGNET Archive Format version number code provided by INTERMAGNET. It takes the form of a binary single byte number ranging from 0 to 255. Zero (0x00) represents version 1.00 and one (0x01) represents version 1.10. The other three bytes of word 15 are reserved for future use and padded with zeros. Word 16 is reserved for future use.

Words 17-5776 contain the minute values of the 4 components (successively X,Y,Z,F or H,D,Z,F) for the day. From 2009 onward, words 5849-5872 always record 999999 (missing value), this is done because the 4th element in the data is a quality check for minute mean data and this quality check is meaningless. Words 5873-5876 store the 4 daily mean values. From 2009 onward, word 5876 always record 999999 (missing value) because the quality check for daily means is also meaningless. From 2009 onward, the last 4 words (5885-5888) are available for each contributing institution. Missing data for minute, hour, and day values are stored as "999999". Missing K-Index values are stored as "999".

4.3.4 IAFV1.00 (2007 and before)

Words 1 to 16 comprise the header section containing a mixture of text and numeric fields, including a 3-letter observatory identification preceded with a space [hex20] (ID) code, the year concatenated with the day of the year, co-latitude, longitude, elevation, reported orientation, originating organization, a D-conversion factor, data quality, instrumentation, K-9, sampling rate and sensor orientation. From 1991 to 2005, the fourth component is the total field from either a scalar (independent) instrument or the total field calculated from the main observatory instrument. INTERMAGNET has a list of which observatories supplied which type of total field value between 1991 and 2005 and this list is available as a spreadsheet in the archive viewer software. The D-conversion factor is a fixed value used only in the graphics portion of the
access software to allow Declination to be plotted in
minutes of arc and equivalent nanoteslas (nT). It is
given as H/3438*10000, where H is the annual mean
value of the horizontal intensity. Example: If H is 16500
D will be 47993(Integer). This conversion factor only
applies to HDZ observatory data supplied before 2005.

ASCII values, such as the observatory ID and
orientation, are also stored as 32-bit words, but are coded
as the hexadecimal byte-string corresponding to the
ASCII string. For example, the string "HDZF" is coded
as the sequence "48 44 5A 46".

Word 11 is the K-9 value for the observatory in nT,
word 12 is the digital sampling rate in msec, and word 13
is the sensor orientation. Sensor orientation could be
XYZF, DIF, UVZ, HDZ, HDZF etc. and should
indicates which components are actually measured. If a
three component sensor orientation is used, a space must
be added at the end. Word 14-15 are reserved for future
use and padded with zeros. In version 1.10 and later,
word 15 have been defined to represent the version
number. Previously, it should have been coded to zero
by IMO, that is the reason this word was chosen for the
version number (zero represents version 1.00). Word 16
is set aside for each contributing institution to use as they
wish, provided it is coded as a 32-bit binary value.

Words 17-5776 contain the minute values of the 4
components (successively X,Y,Z,F or H,D,Z,F) for the
day. Until 2005, the 4th component could contain "F"
from either a scalar or calculated from the vector
instrument. From 2006 onward, the 4th component
contains "F" only if it is measured from a scalar
instrument independent of the other 3 components
otherwise it must be filled with 999999. The values of
the 4 components are stored in tenth-units with an
implied decimal point. Thus, an H value of 21305.6 is
stored (in tenth-nT) as 213056 with a decimal point
implied between the last and next-to-last digits and a D
value of 527.6 is stored (in tenth-minutes) as 5276 also*
with a decimal point implied between the last and next-
to-last digits. Words 5777-5872 are used for the hourly
mean values of the successive 4 components. Words
5873-5876 store the 4 daily mean values. Prior to the
1994 CD-ROM, words 5877-5884 held the 8
(K-Index*10) values for the day. The true IAGA
K-Index could be obtained from these K-Index*10
values by truncating the second (least significant) digit.
From 1994 onward, words 5877-5884 contain the
K-Index*10. Until 1998, word 5885 contained the
equivalent daily amplitude index (Ak). From 1999
onward, word 5885 is reserved for future use and padded
with zeros. The last 3 words (5886-5888) are reserved
for future use and padded with zeros. Missing data for
minute, hour, and day values are stored as "999999".
Missing K-Index and Ak values are stored as "999".

4.4 STORAGE REQUIREMENTS

Each 1-day record requires 23,552 bytes, so a month-
file for January would require 730,112 bytes of storage.
A year of observatory data requires almost 8.6
Megabytes (Mb) of storage. The storage capacity of a
CD-ROM is about 640 Mb. A single sided, single layer
DVD holds about 4.7 Gb, a single sided, double layer
DVD about 8.5Gb.

4.5 INTERMAGNET DVD/CD-ROM
DIRECTORY STRUCTURE

The files on the INTERMAGNET DVD/CD-ROM are
set up in a particular directory structure. The root
directory contains a "README.TXT" file, which is an
ASCII file describing the DVD/CD-ROM and where to
obtain information about it, the software, and
documentation; CDs also hold a "README.EXE" file,
which is an executable version of the README.TXT
file that allows the user to scroll back and forth through
the information.

On the 1991 CD-ROM there are also two
sub-directories. One is labelled "XTRAS", and the other
"MAG1991". The XTRAS directory contains one file
labeled "STRUCTUR.DAT", and another
"PRNSTRUC.EXE". The STRUCTUR.DAT file
provides a schematic of the data structure for the records
on the DVD/CD-ROM and the PRNSTRUC.EXE file
enables the user to obtain a printout of that record
structure.

The MAG1991 directory contains a sub-directory for
each observatory identified by its 3-letter ID code. In
addition, there are sub-directories labeled "1991MAPS",
"CTRY_INF", and "OBSY_INF". The 1991MAPS
directory contains the *.PCX files that are the map
images of each country for use in the access software.
These are labeled by a 3-letter country ID with the PCX
extension, and one labeled "ALL.PCX" for the "All
Countries" option. The CTRY_INF directory contains a
"CTRYLIST.IDX" file that is used internally, *.PCX
files for each country (and one for ALL) that are the
images used to show the flag and organizational Logo
for the different countries, and the README files that
pertain to each country's geomagnetism program
(including a README for the ALL option). The
OBSY_INF subdirectory contains a
"91OBSYDAT.DBF" file that is used internally in the
software.

The individual sub-directories (e.g. BFE for Brorfelde,
TUC for Tucson, etc.) contain the 12 months of data
labeled with the 3-letter ID, 2-character year, 3-letter
month abbreviation, and a "BIN" extension indicating
they are binary files. For example, "BFE91AUG.BIN"
is a file of 31 sequential day-records for Brorfelde, for
1991, for August. In addition, there are the "README.XXX" files for the individual observatory, where the XXX indicates the 3-letter observatory ID.

This sub-directory may also contain a file labeled as XXXYRK.DKA, where the XXX is the 3-letter observatory ID, the YR is the 2-character year value and the K indicates a K-Index file. Originally the DKA extension was used to indicate that the data were generated from a digital algorithm in an ASCII format, however subsequently these files have been used to hold both digitally derived and hand-scaled K indices. Since the 2005 CD-ROM the DKA files have been created by INTERMAGNET using data from the binary IAF file (before 2005 these files were provided by the observatories). These ASCII K-Index files are used, even though the data are in the binary records, because they are much faster to access than paging through the binary records on the DVD/CD-ROM.

### 4.6 INTERMAGNET CD-ROM SOFTWARE

The INTERMAGNET CD-ROM software is a menu-driven program that allows the user to display data in both graphics and text modes. It also allows the user to save the graphics in the form of *.PCX files that can then be imported into other programs that accept the PCX format; and also save the text in the form of ASCII files to the hard drive or floppy disk. Output may also be sent to an Epson-compatible dot-matrix, or Hewlett-Packard Laserjet-compatible printer for both plots and text.

Starting the software brings up a "Welcome" screen, and an ENTER command brings the user into the HOME screen, with menu options for YEAR, COUNTRY, OBSERVATORY, DATE-RANGE, AND MODE-OUTPUT. The "1" and "1" keys allow the user to scroll through the choices, which are highlighted as the user moves through them. Pressing the "ENTER" key selects the highlighted option, and activates pop-up menus with further options. All options may be selected using the 1, 1, and ENTER keys. Selections may also be made with the use of "Hot Keys", which are the first letter of each option, and indicated in the software by use of a different color in the menu choices. Pressing the particular Hot Key activates that menu choice immediately. Hot Keys are indicated in this manual by the use of bold type, for example, S(ave) means that if the "S" key is pressed for the Save option, it is executed immediately. Once all selections have been made, the EXECUTE option retrieves and displays the chosen options. Pressing the "ALT" and "E" keys simultaneously will exit the user back to DOS at any time, and from anywhere within the program.

There are 6 MODE-OUTPUT options: a) minute value plots, b) minute values as text, c) mean hourly value plots, d) mean hourly values as text, e) K-Index values as text, and f) a conversion option that converts data from the 32-bit binary format into the World Data Center (WDC) ASCII format. The WDC format option was included to allow users with existing software designed for this format to output the desired data and import it into their existing programs.

Help screens are available throughout the program with the use of the "F1" key. When the user is in a particular highlighted menu item, the F1 key provides a help screen about that item. In addition, information screens are available about a particular country using the "F4" key, and about the particular observatory using the "F3" key. These option keys appear on a menu bar on the screen when the COUNTRY and/or OBSERVATORY option is highlighted. The user can scroll through these README screens using the "1" and "1" keys, once the F3 or F4 key has been pressed.

Within the program, menu bars located at the top and bottom of the screen, offer a variety of options. A map screen of each country is available, showing the observatories contributing to the CD-ROM from that country, by using the VIEW MAP key once the particular country has been chosen. Also, an ABOUT screen is available for each country showing the organization's address and the names of persons to contact regarding their geomagnetism program. Users can change observatories (within a given country) and date ranges while in the output mode without having to return to the HOME screen. Individual components in the plot outputs may be selected and displayed at an enlarged scale using the COMPONENT option (Hot Key "C") from the menu bar. While in the Component mode, the TOGGLE key toggles on and off a histogram of hourly means and K-Index values (when available) for the minute plots, and the Ak values for the mean hourly values plots. PRINT and SAVE options are also available for both graphics and text modes. Starting with the 1992 CD-ROM, a BASELINE option was made available that provides absolutes and baseline calibration data for each station. These data can be viewed either in the form of a plot for each component, or in text mode showing the observed and adopted values for the year. The plots also show a delta-F plot of the differences between the observed and computed total field (F) for some stations; and the text mode contains a comments section pertaining to baseline jumps and other observatory adjustments.

Other options that are available from the menu bars include a BEGINNING DAY choice that resets the output to the beginning of the selected date-range, a FLOW chart of the software program that indicates where the user is within the program and what outputs are available, and a RESCALE option that allows the user to
set the scale of the plots. This feature disables the auto-scaling of the plots, and enables a user to plot data at a fixed scale for comparison of different days and/or observatories on the same full-range scale. However, if the data cannot fit within the plot range, the Rescale option will override the user-selected scale and auto-scale to fit the data. While in the HOME screen, the P(references) option allows the user to customize certain parameters including the text and background colors, the type of printer being used, and the CD-ROM and output drive letter designations, it is also possible to add CRLF (carriage return / linefeed characters) to the records in any data converted to WDC-files.

Copies of DVD/CD-ROM, software and documentation may be obtained from:

INTERMAGNET DVD/CD-ROM distribution office
Observatoire Magnétique National
Carrefour des 8 routes
F-45340 Chambon la Forêt
FRANCE
Tel: 33 (0) 2-38-33-95-00
Fax: 33 (0) 2-38-33-95-04
Internet: imso@ipgp.fr
CHAPTER 5 SATELLITES

5.1 GEOSTATIONARY SATELLITES

Orbiting the earth, 36,000 km above the equator with approximately 72° of longitude between them are five geostationary satellites, METEOSAT, GOES-East, GOES-West, GMS and INSAT. The operational status of the INSAT satellite, operated by the Indian Meteorological Agency is not clear at the present time, and it is not used for any INTERMAGNET transmissions. The primary function of the other four satellites is to provide regular updates, to meteorological agencies, of cloud and infra-red image data which they use to produce forecasts of weather conditions worldwide. Along with these imaging facilities the satellites can, at regular time intervals, relay data collected from remote ground based transmitters to users equipped with suitable receiving and decoding equipment.

This method of data transmission is being used by many magnetic observatories participating in INTERMAGNET to relay data from observatories in both the northern and southern hemispheres to the INTERMAGNET GINs. Until recently, data from observatories in the southern hemisphere or remote island groups took months, or in some cases years, to reach users; but now, using satellite communications, data from an Antarctic island are available to researchers from an INTERMAGNET GIN within 72 hours of recording.

5.2 METEOSAT

Transmitting through METEOSAT, each Data Collection Platform (DCP) is allocated a one-minute transmission slot every hour. During this time the DCP encodes and transmits, to the satellite, any data input to it during the previous 60 minutes. From the satellite, the data are relayed to the EUMETSAT operations center at Darmstadt, Germany, where they are checked and temporarily stored. The GIN automatically collects the data from EUMETSAT web site. For more information please contact the Paris GIN manager.

5.3 GOES

Observatories transmitting through the GOES East/West satellites output their data every 12 minutes to the satellite and in this case there is no secondary retransmission stage, as is done with METEOSAT. In the GOES system the data are transmitted directly to a receiving GIN where they are made available to users. This form of communication is simpler, but the GOES link does require a much larger receiving antenna as signals transmitted directly from a geostationary satellite are at a very much lower power than those relayed using the METEOSAT retransmission facility. To overcome the necessity for a large 3-5m receiving dish antenna, users in or near the United States may also access GOES East and West transmissions using a DOMSAT (DOMestic SATellite) receiving station. This is a retransmission facility similar to that used with METEOSAT, providing users with a much stronger signal and hence a considerable reduction in the size of the receiving antenna required (1.2 - 1.8m in diameter).

5.4 TRANSMISSION ACCESS

The use of satellites and the timed-transmission slots on any of the geostationary satellites is very closely controlled. Before an observatory can transmit data using a satellite, an application must be made to the relevant controlling body. All transmission equipment used must have been checked and certified to be of an acceptable standard before a licence and a transmission slot can be granted. Also, although it may be possible to gain free access to geostationary satellites, depending on the institute and the use to which the data are being put, the satellite operators may charge users for access.

Two different types of transmission authority may be necessary before an observatory can transmit its data through a satellite to a GIN:

1) Authority to transmit to an Earth orbiting apparatus. This is a licence issued by the government of a particular country which gives an institute permission to operate radio transmission equipment. This type of licence may not be necessary, but prospective participants should check with their respective government departments to ensure that they are not contravening any transmission laws in force in their country.

2) Application must be made to the operators of the satellite which can be accessed from the observatory. Appendix B-2 shows the footprints of geostationary satellites and from this users can decide which satellite should provide the best transmission path. Since satellite positions are sometimes changed, those intending to operate an IMO near the edge of a footprint should contact the satellite operators for more detailed information concerning the satellite accessibility. Most satellite operators have a standard application form. A prospective user should write...
to the operator giving details of the proposed use to which the transmitted data is to be put, a brief description of the project and a request for a transmission slot application form.

If an application form has to be completed, it may include many questions about the operator, site location, and technical questions about the type of DCP, transmission power and whether or not the proposed DCP has been certified for use on this satellite by the satellite operators. To answer these questions, it is usually necessary to contact the DCP supplier.

The completed form is then sent to the respective satellite operator, who, after due deliberation will hopefully issue the applicant with a satellite identification number, a transmission frequency/channel and a specific time slot on the allocated channel.

Alternatively, if the user or the organization to which the user belongs is a member of the World Meteorological Organization (WMO), access to a specific satellite and a transmission slot may be granted simply by quoting an identification number which has been issued by the respective satellite operators to the member state or country.

The length of time slots used varies depending on the satellite which is being accessed. A METEOSAT time slot is 1 minute every hour. On GMS it is 90 seconds every 12 minutes and on GOES, 20 seconds every 12 minutes. During these times users transmit their data. It is essential that the DCP clocks maintain accurate timing, as any transmission outside the allocated time slot will result not only in corruption of the data being transmitted, but also of data transmitted by users on adjacent time slots.

5.5 SATELLITE OPERATORS

1) METEOSAT
   EUMETSAT
   AM Kavalleriesand 31
   D-64295
   Darmstadt
   Germany
   Telephone: 49 61 51 80 77
   FAX: 49 61 51 80 75 55
   INTERNET: ops@eumetsat.de
   WEB: www.eumetsat.de

   Those whose potential IMOs would be serviced by METEOSAT are advised to first contact the PARIS GIN operator for timely information on access to METEOSAT.

2) GOES East and West
   Mr. Jim Abeyta
   NOAA R/E/SE
   325 Broadway
   Boulder, CO 80303
   USA
   Telephone: 1-303-497-5827
   Internet: James.Abeyta@noaa.gov

   Those whose potential IMOs would be serviced by GOES are advised to first contact the GOLDEN GIN operators for timely information on access to GOES.
5.6 SATELLITE SERVICES

Other methods of obtaining permission to transmit via METEOSAT and GOES East and West are:

1) Through MAEDS (Multisatellite Applications Extended Dissemination Service), which is a commercial organization based in France. This company undertakes to arrange a satellite transmission slot on METEOSAT and GOES.

CLS Service MEADS
18, Av. Edouard Belin
Toulouse Cedex 31055
FRANCE

2) Through North American Collection and Location Service (NACL), which is a company providing similar services to those provided by MAEDS.

Mr. Peter Griffith
North American Collection & Location by Satellite
9200 Basil Court, Suite 306
Landover, MD 20785
USA
Telephone: 1-301-341-1814
Fax: 1-301-341-2130

These companies have been given the right by EUMETSAT to market environmental data gathering services.
CHAPTER 6  DATA QUALITY CONTROL

6.1  INTRODUCTION

Quality control methods should be employed in the production of reported, adjusted and definitive data. Total field intensity values that are recorded using a proton precession magnetometer are an excellent tool for monitoring the measurement process that produces component values. The total field values may also be used to estimate the maximum likely range of error for component values. Baseline values are used to adjust component values for long-period, non-random error. A baseline adoption process may be used that provides confidence limits for component 1-minute values. A tabular listing of annual baseline values and a description of baseline adjustments accompany data contained on INTERMAGNET DVDs/CD-ROMs. A graphic display of baselines and differences in computed and recorded total field values are available to users for stations on the INTERMAGNET DVDs/CD-ROMs.

6.2  THE OBSERVATORY MEASUREMENT PROCESS

Magnetic observatories use a variety of magnetometers, electronics, and computer processes to obtain component values of the Earth's magnetic field at 1-minute intervals. The component values recorded depend on the type of variometers used and the orientation of the variometer sensors. A vector diagram of component relationships is shown in figure 1. The reliability of component values may be influenced by many factors:

- orientation of variometer sensors
- stability of variometer piers
- filter techniques used in digitizing values
- temperature coefficients of variometer sensors and electronics
- background noise of sensors and electronics
- orthogonality of variometer sensors
- application of absolute controls
- calibration of magnetometers
- accuracy of pier corrections
- random error inherent in the measurement process
- pier stability
- magnetometer's susceptibility to environmental influences
- activity of the magnetic field during the measurement process
- field gradient

The non-random error in the absolute measurements should be minimized by using standard observatory procedures (see references in section 2.6).

The instruments, electronics, computer processes, and observatory procedures are selected to minimize the negative effects of the above factors. Quality control procedures should be used to monitor these influences.

Component baseline values are computed from absolute measurements and digitally recorded component values. Absolute values of the Earth's magnetic field are measured by an observer and the accuracy of the absolute values depend on several factors:

- observer skill and absence of bias
6.3 COMPUTATION OF BASELINE VALUES

The component baseline values are reported in the format described in Appendix E-4. The general form of the equation for computing the baseline value for an arbitrary component \( W \), is shown below:

\[
W_B(k) = W_O(i:j) - [W_S(k) \times W_M(i:j)]
\]

where:

(i:j) - is the time interval (generally several minutes) for the measurement
(k) - is the k-th time, the average time of the interval (i:j).
\( W_B \) - is the computed baseline value
\( W_O \) - is the observed absolute field value for time interval (i:j).
\( W_S \) - is the scale value of component \( W \) of the variometer sensor. This value is used to convert electrical units to magnetic units. The conversion factor may be automatically applied by computer or electronics to 1-minute values. If the conversion factor is not stable, scale value measurements should be made and recorded for baseline application.
\( W_M \) - is the mean of the 1-minute component values recorded during the time interval (i:j).

![Figure 2 - Baseline values for BESLK observatory year 2003](image-url)
6.4 BASELINE ADOPTION

A number of methods are used in observatory data processing procedures to adopt baselines from observed baseline values. An adopted baseline may be fitted to the baseline values by hand or by a computer algorithm. The baseline values obtained from the adopted baseline for each day are written to a file in the INTERMAGNET baseline format IBFV2.00, (Appendix E-4). The format includes a section for comments pertaining to dates and times of baseline adjustments or changes in instrumentation. These files must be transmitted annually to INTERMAGNET along with 1-minute data for DVD production.

If the baseline is adopted by computer, statistics may be generated to verify that confidence limits for the adopted baseline meet the INTERMAGNET specifications. The confidence limits are computed from the variance of baseline values about the adopted baseline for specific segments of time. Component confidence limits for the annual adopted baseline may be estimated by pooling the variance of the segments. This may provide the user with a quantitative measure of the possible error in component values.

Figure 2 shows observed values (circles) and adopted baseline values (dots) for magnetic field components X, Y, and Z for Belsk observatory during 2003. The time series of F-P total field differences, defined in section 6.5, corresponds to the time series of adopted baseline values.

6.5 THE COMPUTATION OF TOTAL FIELD DIFFERENCES

One-minute total field values should be recorded in parallel with 1-minute component values taken at the same time. The total field difference (F-P) is the total field computed from component values (baseline-adjusted) minus the total field value recorded by a total field magnetometer. The equations used for computing F-P values depend on the variometer orientation. The equation for computing F-P for a variometer orientated to measure components XYZ is:

\[(F-P)_i = \left( (B_{X_i}+X_i)^2 + (B_{Y_i}+Y_i)^2 + (B_{Z_i}+Z_i)^2 \right)^{1/2} - F_i + PDF \]

and for HDZ orientation,

\[(F-P)_i = \left( (B_{H_i}+H_{Ni})^2 + H_{Ei}^2 + (B_{Z_i}+Z_i)^2 \right)^{1/2} - F_i + PDF \]

where:

- \(i\) is the time of the difference computation. The time unit may be 1-minute, mean hourly, or daily differences.
- \(B\) denotes the baseline value for components H, X, Y, or Z.
- \(F\) is the total field value recorded using a total field magnetometer.
- PDF is the total field pier difference, the difference between the total field value at the sensor, and total field value at the absolute pier.
- \(H_N\) is the vector field of the horizontal intensity recorded by the H sensor, as shown in figure 3.
- \(H_E\) is the vector field of the horizontal intensity recorded by the D sensor. The change in declination (\(\delta D\)) is relative to the declination of the H sensor at orientation (\(D_o\))

\[D_o = D_i - \text{ATAN}\left[ H_{Ei}/(B_{H_i}+H_{Ni}) \right] \]
\[D_i = \text{absolute observed declination} \]

The F-P values may be computed from reported, adjusted or definitive data. Time series graphs of the F-P
values may be produced easily and quickly at GINs. Programs may be used to produce the F-P graphs in real-time to enable GIN operators to continuously monitor the performance of those observatories transmitting to the GIN by satellite communication. The F-P values may be used for correlation studies to isolate environmental influences. The value of this technique decreases when one component dominates the others.

The errors in component values ($\Delta X$, $\Delta Y$, $\Delta Z$) give rise to an error in $F$:

$$\Delta F = \frac{X \Delta X}{F} + \frac{Y \Delta Y}{F} + \frac{Z \Delta Z}{F}.$$  

If we assume no change in $Y$ ($\Delta Y$) and $Z$ ($\Delta Z$), then the minimum detectable error that might be attributed to the $X$ component would be: $\Delta X = F \frac{\Delta F}{X}$. The minimum detectable error may be estimated for each component. For the HDZ sensor orientation similar results arise for $H$ and $Z$:

$$\Delta F = \frac{H \Delta H}{F} + \frac{Z \Delta Z}{F}.$$  

No inference can be made concerning $D$.

### 6.6 SUMMARY

Tools that might be used for quality control of reported, adjusted and definitive data have briefly been described. INTERMAGNET is establishing standards of comparison such as the graphs of baselines and F-P values. Participating observatories may evaluate the performance of their operations relative to the results of other observatories. Participants communicate with other members on instrumentation procedures to improve the quality of INTERMAGNET observatory data.
CHAPTER 7  WORLD WIDE WEB

7.1  INTRODUCTION

The INTERMAGNET web site provides background information about INTERMAGNET, its structure and its participating organizations, countries and IMOs (INTERMAGNET Magnetic Observatories). It offers access to its various products including magnetograms and data files of Reported and Adjusted Minute Mean values from all the IMOs, the Annual DVD/CD-ROM of Definitive Data, and the Technical Reference Manual. The INTERMAGNET application form can also be obtained from the web site.

7.2  WEB SITE ADDRESS

INTERMAGNET web site address is: www.intermagnet.org
APPENDIX A-1

INTERMAGNET TERMINOLOGY

REPORTED Data:
Data as output by an observatory, transmitting through
a satellite or using E-Mail. REPORTED data have not
had any baseline corrections applied, may contain spikes
and may have missing values. When ADJUSTED data
are available, REPORTED data are removed from online
access.

ADJUSTED Data:
Each observatory or its parent institute is allowed to
modify REPORTED data files to produce ADJUSTED
data, with a goal of 7 days after transmission. These
adjustments may be to modify baselines, remove spikes,
fill gaps etc. on any day file. When data are missing
from an ADJUSTED data file, these data may be input
to a GIN in a later message. This new message file can
be transmitted to a GIN with the 'A' flag set in byte 25 of
each hourly block header (Appendix E-3). ADJUSTED
data are maintained online until the annual DVD is
available. They are then archived by the GIN and only
available thereafter by special arrangement.

DEFINITIVE Data:
This describes observatory data which have been
corrected for baseline variations and which have had
spikes removed and gaps filled where possible.
DEFINITIVE data have each block header byte 25 set to
'D' (Appendix E-3), and the quality of the data is such
that in this form they would be used for inclusion into
Observatory Year Books, input to World Data Centers
and included in INTERMAGNET DVDs.

Reference Measurement (RM):
Values provided automatically by an IMO using 2
independent instruments for inter-comparison.
Reference Measurements are provided by the institute
operating the observatory site using satellite
communications to INTERMAGNET GINs using the
Format IMFV2.83. The RMs are applied to reported
data to produce adjusted data and to supplement baseline
control.

Magnetic observatory:
A permanent installation of magnetometers capable of
providing magnetic field values with an absolute
accuracy of better than 5 nT over a period ranging from
DC to approximately 1 Sec.

IMO:
An INTERMAGNET Magnetic Observatory (IMO) is
a magnetic observatory equipped with magnetometers,
clock, control electronics, transmitting equipment and a
data collection platform (DCP), residing at the magnetic
observatory site. The operation and equipment must
meet INTERMAGNET standards and specifications.

GIN:
A Geomagnetic Information Node contains satellite
receiving equipment and computer processing facilities
and is linked to communications networks. GINs collect
magnetic observatory data in near real-time and store
them in a database. These data, indices and other
products may be readily accessed by INTERMAGNET
users, usually by e-mail.

NESS binary:
For GOES users, each 16-bit binary word is encoded
as 3 pseudo ASCll bytes, so that the 126 bytes of
IMFV2.83 data are encoded as 189 bytes NESS binary
(see Appendix E-2).

Time stamp:
The time of the first sample of the data block:
- Greenwich day 1 through 366 encoded as a 12-bit
  binary number.
- Minute of the Greenwich day : 0 through 1439
  encoded as a 12-bit binary number (see Appen-
dices E-1 and E-2).

Offset:
The component offset values determined by the
INTERMAGNET coding algorithm that has been
applied to recorded data for coding data stored in the
"minute value" section of Format IMFV2.83 (see
Appendix E-1).

Flags:
Two bytes "Flags #1" and "Flags #2" (bytes 8 and 9)
of Format IMFV2.83, are reserved for IMO status
information (see Appendix E-1).
<table>
<thead>
<tr>
<th>ID3</th>
<th>OBSERVATORY</th>
<th>GEOGRAPHIC</th>
<th>GEOMAGNETIC</th>
<th>ORG</th>
<th>INTERMAGNET DVD/CD-ROM</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>AAA Alma-Ata</td>
<td>43.25</td>
<td>76.92</td>
<td>152.7</td>
<td>IIRK</td>
</tr>
<tr>
<td></td>
<td>AAE Addis Ababa</td>
<td>9.02</td>
<td>38.77</td>
<td>111.8</td>
<td>AAU/IPGP</td>
</tr>
<tr>
<td></td>
<td>ABG Alibag</td>
<td>18.63</td>
<td>72.87</td>
<td>146.2</td>
<td>IIG</td>
</tr>
<tr>
<td></td>
<td>ABK Abisko</td>
<td>68.36</td>
<td>18.82</td>
<td>114.7</td>
<td>SGU</td>
</tr>
<tr>
<td></td>
<td>AIA Akademik</td>
<td>-65.25</td>
<td>295.75</td>
<td>5.5</td>
<td>ISRU</td>
</tr>
<tr>
<td></td>
<td>ALE Alert</td>
<td>82.50</td>
<td>-62.35</td>
<td>157.1</td>
<td>GSC</td>
</tr>
<tr>
<td></td>
<td>AMS Martin de</td>
<td>-37.80</td>
<td>177.57</td>
<td>144.3</td>
<td>EOST</td>
</tr>
<tr>
<td></td>
<td>API Aplia</td>
<td>-13.81</td>
<td>188.22</td>
<td>262.7</td>
<td>DAFWS</td>
</tr>
<tr>
<td></td>
<td>AQU Aigua</td>
<td>42.38</td>
<td>13.32</td>
<td>85.5</td>
<td>INDG</td>
</tr>
<tr>
<td></td>
<td>ARS Arti</td>
<td>56.43</td>
<td>58.57</td>
<td>140.1</td>
<td>UBRAS</td>
</tr>
<tr>
<td></td>
<td>ASC Ascension</td>
<td>-7.95</td>
<td>345.62</td>
<td>56.6</td>
<td>BGS</td>
</tr>
<tr>
<td></td>
<td>ASP Alice Spring</td>
<td>-23.76</td>
<td>133.88</td>
<td>208.2</td>
<td>GA</td>
</tr>
<tr>
<td></td>
<td>BDV Budkov</td>
<td>49.07</td>
<td>14.02</td>
<td>97.7</td>
<td>ASCR</td>
</tr>
<tr>
<td></td>
<td>BEL Belsk</td>
<td>51.84</td>
<td>20.79</td>
<td>105.2</td>
<td>PAS</td>
</tr>
<tr>
<td></td>
<td>BFE Brofjelda</td>
<td>55.63</td>
<td>11.67</td>
<td>81.2</td>
<td>ING</td>
</tr>
<tr>
<td></td>
<td>BFO Black Forest</td>
<td>48.33</td>
<td>3.83</td>
<td>88.2</td>
<td>GUKS</td>
</tr>
<tr>
<td></td>
<td>BLC Baker Lake</td>
<td>64.33</td>
<td>-96.03</td>
<td>322.1</td>
<td>GSC</td>
</tr>
<tr>
<td></td>
<td>BMT Beijing</td>
<td>40.06</td>
<td>116.18</td>
<td>187.0</td>
<td>CHAS</td>
</tr>
<tr>
<td></td>
<td>BNG Bangui</td>
<td>4.43</td>
<td>18.56</td>
<td>91.1</td>
<td>IRD</td>
</tr>
<tr>
<td></td>
<td>BOU Boulder</td>
<td>40.14</td>
<td>-105.24</td>
<td>320.6</td>
<td>USGS</td>
</tr>
<tr>
<td></td>
<td>BOX Barox</td>
<td>58.03</td>
<td>38.97</td>
<td>124.1</td>
<td>RAS/IPGP</td>
</tr>
<tr>
<td></td>
<td>BRW Barrow</td>
<td>71.32</td>
<td>-156.62</td>
<td>246.2</td>
<td>USGS</td>
</tr>
<tr>
<td></td>
<td>BSL Bay St.</td>
<td>30.35</td>
<td>-89.64</td>
<td>339.8</td>
<td>USGS</td>
</tr>
<tr>
<td></td>
<td>CBB Cambridge</td>
<td>69.10</td>
<td>-105.00</td>
<td>303.1</td>
<td>GSC</td>
</tr>
<tr>
<td></td>
<td>CLF Champon la</td>
<td>47.02</td>
<td>2.27</td>
<td>85.7</td>
<td>IPGP</td>
</tr>
<tr>
<td></td>
<td>CMO College</td>
<td>64.87</td>
<td>-147.86</td>
<td>261.7</td>
<td>USGS</td>
</tr>
<tr>
<td></td>
<td>CNB Canberra</td>
<td>-35.32</td>
<td>149.36</td>
<td>226.9</td>
<td>GA</td>
</tr>
<tr>
<td></td>
<td>CNH Changchung</td>
<td>44.08</td>
<td>124.86</td>
<td>195.2</td>
<td>CEA</td>
</tr>
<tr>
<td></td>
<td>CSY Casey Station</td>
<td>-66.28</td>
<td>11.53</td>
<td>182.0</td>
<td>GA</td>
</tr>
<tr>
<td></td>
<td>CTA Charters</td>
<td>-20.08</td>
<td>146.25</td>
<td>221.0</td>
<td>GA</td>
</tr>
<tr>
<td></td>
<td>CTT Port Alfred</td>
<td>-46.44</td>
<td>51.90</td>
<td>113.3</td>
<td>EOST</td>
</tr>
<tr>
<td></td>
<td>DED Deadhorse</td>
<td>70.36</td>
<td>211.21</td>
<td>327.3</td>
<td>USGS</td>
</tr>
<tr>
<td></td>
<td>DLR Del Rio</td>
<td>29.50</td>
<td>-100.92</td>
<td>38.3</td>
<td>327.3</td>
</tr>
<tr>
<td></td>
<td>DMC Dome C</td>
<td>-75.25</td>
<td>124.17</td>
<td></td>
<td>EOST/INGV</td>
</tr>
<tr>
<td></td>
<td>DOU Dourbes</td>
<td>50.10</td>
<td>4.60</td>
<td>88.9</td>
<td>RMIB</td>
</tr>
<tr>
<td></td>
<td>DRV Dumont d'Urv</td>
<td>-66.37</td>
<td>140.01</td>
<td>231.2</td>
<td>EOST</td>
</tr>
<tr>
<td></td>
<td>DUR Durna</td>
<td>41.39</td>
<td>14.28</td>
<td></td>
<td>ING</td>
</tr>
<tr>
<td></td>
<td>EBR De L'Ebre</td>
<td>40.82</td>
<td>0.49</td>
<td>81.3</td>
<td>IGNS</td>
</tr>
<tr>
<td></td>
<td>ESK Eskdalemuir</td>
<td>55.32</td>
<td>-3.20</td>
<td>83.8</td>
<td>BGS</td>
</tr>
<tr>
<td></td>
<td>EYR Eyrewell</td>
<td>-43.42</td>
<td>172.35</td>
<td>253.8</td>
<td>IGN</td>
</tr>
<tr>
<td></td>
<td>FCC Fort Church</td>
<td>58.77</td>
<td>-94.10</td>
<td>328.3</td>
<td>GSC</td>
</tr>
<tr>
<td></td>
<td>FRD Frederiksburg</td>
<td>38.20</td>
<td>-77.37</td>
<td>353.4</td>
<td>USGS</td>
</tr>
<tr>
<td></td>
<td>FRN Fresno</td>
<td>37.09</td>
<td>-119.72</td>
<td>305.3</td>
<td>USGS</td>
</tr>
<tr>
<td></td>
<td>FUR Furstenfeldbruck</td>
<td>48.17</td>
<td>11.28</td>
<td>94.6</td>
<td>UMUN</td>
</tr>
<tr>
<td></td>
<td>GCK Grocka</td>
<td>44.30</td>
<td>102.30</td>
<td>102.4</td>
<td>CCG</td>
</tr>
<tr>
<td></td>
<td>GDH Godthavn</td>
<td>69.25</td>
<td>-53.53</td>
<td>34.0</td>
<td>DMI</td>
</tr>
<tr>
<td></td>
<td>GLN Glenlea</td>
<td>49.60</td>
<td>-97.10</td>
<td>327.8</td>
<td>GSC</td>
</tr>
<tr>
<td></td>
<td>GNA Nangara</td>
<td>-31.78</td>
<td>115.95</td>
<td>188.9</td>
<td>GA</td>
</tr>
<tr>
<td></td>
<td>GUA Guam</td>
<td>13.59</td>
<td>144.87</td>
<td>215.7</td>
<td>USGS</td>
</tr>
<tr>
<td></td>
<td>GUI Guim-Tenerife</td>
<td>28.32</td>
<td>-16.43</td>
<td>60.6</td>
<td>IGNS</td>
</tr>
<tr>
<td></td>
<td>GZH Zhaoqing</td>
<td>22.97</td>
<td>112.45</td>
<td>181.0</td>
<td>SBI</td>
</tr>
<tr>
<td></td>
<td>HAD Hartland</td>
<td>51.00</td>
<td>-4.48</td>
<td>80.2</td>
<td>BGS</td>
</tr>
<tr>
<td></td>
<td>HBT Hartebeesthoek</td>
<td>-25.88</td>
<td>27.71</td>
<td>94.4</td>
<td>HMO</td>
</tr>
<tr>
<td></td>
<td>HER Hermanus</td>
<td>-34.43</td>
<td>19.23</td>
<td>84.0</td>
<td>HMO</td>
</tr>
<tr>
<td></td>
<td>HLP HEL</td>
<td>54.60</td>
<td>18.82</td>
<td>104.6</td>
<td>PAS</td>
</tr>
<tr>
<td></td>
<td>HON Honolulu</td>
<td>21.32</td>
<td>-158.00</td>
<td>269.7</td>
<td>USGS</td>
</tr>
<tr>
<td></td>
<td>HRB Hurbanovo</td>
<td>46.86</td>
<td>18.19</td>
<td>101.1</td>
<td>SAS</td>
</tr>
<tr>
<td></td>
<td>HRN Hornsund</td>
<td>77.00</td>
<td>15.55</td>
<td>126.0</td>
<td>PAS</td>
</tr>
<tr>
<td></td>
<td>HUA Huayayo</td>
<td>-12.06</td>
<td>294.67</td>
<td>356.5</td>
<td>IGP</td>
</tr>
<tr>
<td></td>
<td>HYB Hyderabad</td>
<td>17.41</td>
<td>78.56</td>
<td>151.9</td>
<td>NGRI</td>
</tr>
</tbody>
</table>
## APPENDIX B-1 (Cont'd)

### OBSERVATORIES PARTICIPATING IN INTERMAGNET

<table>
<thead>
<tr>
<th>IMO</th>
<th>OBSERVATORY</th>
<th>GEOGRAPHIC</th>
<th>GEOMAGNETIC</th>
<th>ORG</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>IPM</td>
<td>Isla Pascua Mataveri</td>
<td>X -27.17</td>
<td>DMC/IPGP</td>
</tr>
<tr>
<td>3</td>
<td>IGA</td>
<td>Iqaluit</td>
<td>X 63.75</td>
<td>GSC</td>
</tr>
<tr>
<td>4</td>
<td>IRT</td>
<td>Irkutsk</td>
<td>X 52.17</td>
<td>ISTPSB</td>
</tr>
<tr>
<td>5</td>
<td>IZV</td>
<td>Iznik</td>
<td>X 40.50</td>
<td>KOERI</td>
</tr>
<tr>
<td>6</td>
<td>KAK</td>
<td>Kakioka</td>
<td>X 36.23</td>
<td>JMA</td>
</tr>
<tr>
<td>7</td>
<td>KMA</td>
<td>Kakadu</td>
<td>X -12.69</td>
<td>GA</td>
</tr>
<tr>
<td>8</td>
<td>KIV</td>
<td>Kiev</td>
<td>X 50.72</td>
<td>NASU</td>
</tr>
<tr>
<td>9</td>
<td>KMH</td>
<td>Keetmanshoop</td>
<td>X -26.54</td>
<td>HMO</td>
</tr>
<tr>
<td>10</td>
<td>KNY</td>
<td>Kanoya</td>
<td>X 31.42</td>
<td>JMA</td>
</tr>
<tr>
<td>11</td>
<td>KOU</td>
<td>Kourou</td>
<td>X 5.10</td>
<td>IGPM</td>
</tr>
<tr>
<td>12</td>
<td>LER</td>
<td>Lerwick</td>
<td>X 60.13</td>
<td>BGS</td>
</tr>
<tr>
<td>13</td>
<td>LNP</td>
<td>Lupping</td>
<td>X 25.00</td>
<td>MTC</td>
</tr>
<tr>
<td>14</td>
<td>LOV</td>
<td>Lovo</td>
<td>X 59.40</td>
<td>SGU</td>
</tr>
<tr>
<td>15</td>
<td>LRM</td>
<td>Learmonth</td>
<td>X -22.22</td>
<td>GA</td>
</tr>
<tr>
<td>16</td>
<td>LVC</td>
<td>Lycksele</td>
<td>X 64.61</td>
<td>SGU</td>
</tr>
<tr>
<td>17</td>
<td>LZH</td>
<td>Lanzhou</td>
<td>X 36.10</td>
<td>CEA/IPGP</td>
</tr>
<tr>
<td>18</td>
<td>MAB</td>
<td>Manhay</td>
<td>X 50.30</td>
<td>RIMB</td>
</tr>
<tr>
<td>19</td>
<td>MAW</td>
<td>Mawson</td>
<td>X 67.60</td>
<td>GA</td>
</tr>
<tr>
<td>20</td>
<td>MBB</td>
<td>Moil Bay</td>
<td>X 76.20</td>
<td>GSC</td>
</tr>
<tr>
<td>21</td>
<td>MBO</td>
<td>Mbour</td>
<td>X 14.38</td>
<td>IRD</td>
</tr>
<tr>
<td>22</td>
<td>MQP</td>
<td>Macquarie</td>
<td>X -54.50</td>
<td>GA</td>
</tr>
<tr>
<td>23</td>
<td>MEG</td>
<td>Meanook</td>
<td>X 54.62</td>
<td>GSC</td>
</tr>
<tr>
<td>24</td>
<td>MGD</td>
<td>Magadan</td>
<td>X 60.05</td>
<td>IKIR</td>
</tr>
<tr>
<td>25</td>
<td>MID</td>
<td>Midway</td>
<td>X 28.21</td>
<td>USGS</td>
</tr>
<tr>
<td>26</td>
<td>MMB</td>
<td>Mememetsu</td>
<td>X 43.90</td>
<td>JMA</td>
</tr>
<tr>
<td>27</td>
<td>NAC</td>
<td>Narssassuq</td>
<td>X 61.16</td>
<td>DMI</td>
</tr>
<tr>
<td>28</td>
<td>NCG</td>
<td>Nagycen</td>
<td>X 47.63</td>
<td>HAS</td>
</tr>
<tr>
<td>29</td>
<td>NEW</td>
<td>Newport</td>
<td>X 46.88</td>
<td>USGS</td>
</tr>
<tr>
<td>30</td>
<td>NGK</td>
<td>Niemegk</td>
<td>X 52.07</td>
<td>GFZP</td>
</tr>
<tr>
<td>31</td>
<td>NUR</td>
<td>Nurmiarvi</td>
<td>X 57.70</td>
<td>FMI</td>
</tr>
<tr>
<td>32</td>
<td>NVS</td>
<td>Novosibirsk</td>
<td>X 54.85</td>
<td>RAS</td>
</tr>
<tr>
<td>33</td>
<td>OTT</td>
<td>Ottawa</td>
<td>X 45.40</td>
<td>X</td>
</tr>
<tr>
<td>34</td>
<td>PAF</td>
<td>Port-aux-Francais</td>
<td>X -49.35</td>
<td>X</td>
</tr>
<tr>
<td>35</td>
<td>PAG</td>
<td>Panaguristhe</td>
<td>X 42.52</td>
<td>BAS</td>
</tr>
<tr>
<td>36</td>
<td>PBB</td>
<td>Poste-de-la-Baleine</td>
<td>X 55.30</td>
<td>GSC</td>
</tr>
<tr>
<td>37</td>
<td>PEG</td>
<td>Peerari</td>
<td>X 30.08</td>
<td>JIGE</td>
</tr>
<tr>
<td>38</td>
<td>PHU</td>
<td>Phuthuy</td>
<td>X 21.03</td>
<td>VAST/IPGP</td>
</tr>
<tr>
<td>39</td>
<td>PPT</td>
<td>Pamatai</td>
<td>X -17.57</td>
<td>IPGP</td>
</tr>
<tr>
<td>40</td>
<td>PST</td>
<td>Port Stanley</td>
<td>X -51.70</td>
<td>IPG</td>
</tr>
<tr>
<td>41</td>
<td>QSB</td>
<td>Qsaybeh</td>
<td>X 33.87</td>
<td>X</td>
</tr>
<tr>
<td>42</td>
<td>RES</td>
<td>Resolute</td>
<td>X 74.70</td>
<td>BAS</td>
</tr>
<tr>
<td>43</td>
<td>SBA</td>
<td>Scott Base</td>
<td>X -77.85</td>
<td>X</td>
</tr>
<tr>
<td>44</td>
<td>SFS</td>
<td>San Fernando</td>
<td>X 36.67</td>
<td>X</td>
</tr>
<tr>
<td>45</td>
<td>SHU</td>
<td>Shumagin</td>
<td>X 55.35</td>
<td>USGS</td>
</tr>
<tr>
<td>46</td>
<td>SIT</td>
<td>Sitka</td>
<td>X 57.06</td>
<td>USGS</td>
</tr>
<tr>
<td>47</td>
<td>SJG</td>
<td>San Juan</td>
<td>X 18.11</td>
<td>USGS</td>
</tr>
<tr>
<td>48</td>
<td>QSB</td>
<td>Qsaybeh</td>
<td>X 33.87</td>
<td>X</td>
</tr>
<tr>
<td>49</td>
<td>RES</td>
<td>Resolute</td>
<td>X 74.70</td>
<td>BAS</td>
</tr>
<tr>
<td>50</td>
<td>SBA</td>
<td>Scott Base</td>
<td>X -77.85</td>
<td>X</td>
</tr>
<tr>
<td>51</td>
<td>SFS</td>
<td>San Fernando</td>
<td>X 36.67</td>
<td>X</td>
</tr>
<tr>
<td>52</td>
<td>SHU</td>
<td>Shumagin</td>
<td>X 55.35</td>
<td>USGS</td>
</tr>
<tr>
<td>53</td>
<td>SIT</td>
<td>Sitka</td>
<td>X 57.06</td>
<td>USGS</td>
</tr>
<tr>
<td>54</td>
<td>SJG</td>
<td>San Juan</td>
<td>X 18.11</td>
<td>USGS</td>
</tr>
<tr>
<td>55</td>
<td>SOD</td>
<td>Sodankyl</td>
<td>X 67.37</td>
<td>USGS</td>
</tr>
<tr>
<td>56</td>
<td>SPT</td>
<td>San Pablo-Toledo</td>
<td>X 39.55</td>
<td>X</td>
</tr>
<tr>
<td>57</td>
<td>STJ</td>
<td>St. John's</td>
<td>X 47.60</td>
<td>GSC</td>
</tr>
<tr>
<td>58</td>
<td>SUA</td>
<td>Surlari</td>
<td>X 44.88</td>
<td>IGME</td>
</tr>
<tr>
<td>59</td>
<td>TAM</td>
<td>Tamarasasset</td>
<td>X 22.79</td>
<td>81.8CRAAGIPGP</td>
</tr>
<tr>
<td>60</td>
<td>TAN</td>
<td>Antananarivo</td>
<td>X -18.92</td>
<td>115.8IOGA/EOST</td>
</tr>
<tr>
<td>61</td>
<td>TDC</td>
<td>Tristan da Cunha</td>
<td>X -37.07</td>
<td>DTU</td>
</tr>
<tr>
<td>62</td>
<td>TEO</td>
<td>Teolyucna</td>
<td>X 19.75</td>
<td>IGM</td>
</tr>
<tr>
<td>63</td>
<td>TIL</td>
<td>Thule</td>
<td>X 77.47</td>
<td>DMI</td>
</tr>
<tr>
<td>64</td>
<td>THY</td>
<td>Tihany</td>
<td>X 46.9</td>
<td>ELGI</td>
</tr>
<tr>
<td>65</td>
<td>TIX</td>
<td>Tixie Bay</td>
<td>X 71.58</td>
<td>X</td>
</tr>
<tr>
<td>66</td>
<td>TRW</td>
<td>Trelew</td>
<td>X -43.26</td>
<td>5.6 UNLPRMB</td>
</tr>
<tr>
<td>67</td>
<td>TSU</td>
<td>Tsumeb</td>
<td>X -19.20</td>
<td>HMO</td>
</tr>
</tbody>
</table>

**INTERMAGNET DVD/CD-ROM**

<table>
<thead>
<tr>
<th>IMO</th>
<th>GEOGRAPHIC</th>
<th>GEOMAGNETIC</th>
<th>ORG</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>9 9 9 9 9 9 9 9 9 9 9 9 9 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Version 4.6 (2012)**

- 32 -
## APPENDIX B-1 (Cont'd)

### OBSERVATORIES PARTICIPATING IN INTERMAGNET

<table>
<thead>
<tr>
<th>IMO</th>
<th>GEOGRAPHIC</th>
<th>GEOMAGNETIC</th>
<th>ORG</th>
<th>INTERMAGNET DVD/CD-ROM</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>LAT</td>
<td>LON</td>
<td>9 9 9 9 9 9 9 9</td>
<td>1 1 1 1 1 1 1 1 1</td>
</tr>
<tr>
<td>ID3</td>
<td></td>
<td></td>
<td>9 9 9 9 9 9 9 9</td>
<td>2 2 2 2 2 2 2 2 2</td>
</tr>
<tr>
<td>1</td>
<td>LAT</td>
<td>LON</td>
<td>9 9 9 9 9 9 9 9</td>
<td>3 3 3 3 3 3 3 3 3</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>9 9 9 9 9 9 9 9</td>
<td>4 4 4 4 4 4 4 4 4</td>
</tr>
</tbody>
</table>

| TUC | Tucson     | X 32.18    | -110.73           | USGS       |
| UPS | Uppsala    | X 59.90    | 17.35             | SGU        |
| VAL | Valletta   | X 51.93    | -10.25            | IMS        |
| VIC | Victoria   | X 48.52    | -123.42           | GSC        |
| VSS | Vassouras  | X -22.40   | -43.65            | ONB        |
| WMQ | Urumqi     | X 43.81    | 87.71             | CEA        |
| WNG | Wingst     | X 53.74    | 9.07              | GFZP       |
| YAK | Yakutsk    | X 61.96    | 129.66            | ICRA       |
| YKC | Yellowknife| X 62.47    | -114.47           | GSC        |

TOTAL 129 TOTAL 445566677888991911

AAU - Addis Ababa University
ASCR - Academy of Sciences of the Czech Republic
BAS - Bulgarian Academy of Sciences
BGS - British Geological Survey
CEA - China Earthquake Administration
CHAS - Chinese Academy of Sciences
CRAAG - Centre de Recherche en Astronomie, Astrophysique et Géophysique d'Algérie
DAFWS - Dept of Agriculture and Fisheries Western Samoa
DMC - Dirección Meteorologica de Chile
DMI - Danish Meteorological Institute
DTU - Denmark Technical University
ELGI - Eotvos Lorand Geophysical Institute
EOST - Ecole et Observatoire des Sciences de la Terre, Strasbourg
FASL - Finnish Academy of Science and Letters
FMI - Finnish Meteorological Institute
GA - Geoscience Australia
GCG - Geomagnetic College Grocka
GFZP - GeoForschungszentrum Potsdam
GGUKS - Geowissenschaftliches Gemeinschaftsobservatorium der Universitäten Karlsruhe und Stuttgart
GSC - Geological Survey of Canada
HAS - Hungarian Academy of Science
HMO - Hermanus Magnetic Observatory
ICRA - Institute of Cosmophysical Research and Aeronomy, Russia
IGM - Instituto de Geofísica, Mexico
IGME - Institute of Geology and Mineral Exploration, Greece
IGN - Institute of Geological and nuclear Sciences, New Zealand
IGNS - Instituto Geografico Nacional, Spain
IGNSL - Institute of Geological and Nuclear Sciences Limited
IGP - Instituto Geofísico del Peru
IGR - Geological Institute of Romania

IGU - Institute of geophysics, Ukraine
IIG - Indian Institute of Geomagnetism
IIRK - Institute of the Ionosphere of Republic Kazakhstan
IKIR - Institute of Cosmophysical Researches and Radio Wave Propagation, Russia
IMS - Irish Meteorological Service
INDG - Istituto Nazionale Di Geofisica, Italy
INGV - Istituto Nazionale di Geofisica e Vulcanologia, Italy
IOGA - Institut et Observatoire Géophysique d'Antananarivo, Université d'Antananarivo
IPGP - Institut de Physique du Globe de Paris
ISTPSB - Institute of Solar-Terrestrial Physics of Siberian
IRD - Institut de Recherche pour le développement, Paris
ISRU - Institute of Space Research, Ukraine
IZMIRAN - Institut Zemnovo Magnetiska Ionosfery I Rasprostranenya Ridiyovol
JMA - Japan Meteorological Agency
KOERI - Kandilli Observatory and Earthquake Research Institute
LISCSB - Lanzhou Institute of Seismology, China Seismological Bureau
MTC - Ministry of Transportation and Communications, China (Taiwan)
NASU - Institute of Geophysics NAS of Ukraine
NCGR - National Center for Geophysical Research, Beirut
NGRI - National Geophysical Research Institute, Uppal Roa
ONB - Observatorio nacional, Brasil
PAS - Polish Academy of Sciences
RAS - Russian Academy of Sciences
RMIB - Royal Meteorological Institute of Belgium
ROA - Real Instituto y Observatorio de la Armada
SAS - Slovak Academy of Sciences
SBG - Seismological Bureau of Guangdong
SGU - Geological Survey of Sweden
UBRAS - Ural Branch of Russian Academy of Sciences
UMUN - University of Munich
UNLP - Universidad Nacional de La Plata, Argentina
USGS - United States Geological Survey
VAST - Vietnam Academy of Science and Technology
VNCST - Vietnam National Center for Science and Technology
### APPENDIX C-1

**IAFV2.10 INTERMAGNET ARCHIVE FORMAT**

**BINARY DATA STRUCTURE FORMAT-32 BIT WORDS**

<table>
<thead>
<tr>
<th>WORD</th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>HEADER</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Station ID</td>
<td>eg: BOU = HEX(20 42 4F 55)</td>
</tr>
<tr>
<td></td>
<td>- Year</td>
<td>eg: 1989001; year 1989, day January 01</td>
</tr>
<tr>
<td></td>
<td>- Day Num</td>
<td>(90° - Latitude) * 1000</td>
</tr>
<tr>
<td></td>
<td>- Co-Latitude</td>
<td>East Longitude * 1000</td>
</tr>
<tr>
<td></td>
<td>- Longitude</td>
<td>elevation in meters above sea level</td>
</tr>
<tr>
<td></td>
<td>- Elevation</td>
<td>eg: XYZG = HEX(58 59 5A 47) (or HDZG, XYZ, HDZ)</td>
</tr>
<tr>
<td></td>
<td>- Orientation</td>
<td>eg: DMI = HEX(20 44 4D 49)</td>
</tr>
<tr>
<td></td>
<td>- Source</td>
<td>eg: GC = HEX (49 4D 41 47)</td>
</tr>
<tr>
<td></td>
<td>- Data Quality</td>
<td>IMAG = HEX (49 4D 41 47)</td>
</tr>
<tr>
<td></td>
<td>- Instrumentation</td>
<td>eg: LC(Linear Core) = HEX(20 20 4C 43) (or RC(Ring Core))</td>
</tr>
<tr>
<td></td>
<td>- K9 value in nT</td>
<td>eg: 750</td>
</tr>
<tr>
<td></td>
<td>- Sampling rate (ms)</td>
<td>eg: XYZF, DIF, UVZ, HDZ, HDZF etc.</td>
</tr>
<tr>
<td></td>
<td>- Sensor orientation</td>
<td>eg: YYMM = 0806 (June 2008)</td>
</tr>
<tr>
<td></td>
<td>- Publication Date</td>
<td>HEX (03 00 00 00) version 2.10</td>
</tr>
<tr>
<td></td>
<td>- Reserved for future use</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td><strong>ONE MINUTE DATA</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 1440 mean minute values - element 1 (one day). Missing value = 999999</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 1440 mean minute values - element 2 (one day). Missing value = 999999</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 1440 mean minute values - element 3 (one day). Missing value = 999999</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 1440 mean minute values - element 4 (one day). Missing value = 999999</td>
<td></td>
</tr>
<tr>
<td>5776</td>
<td><strong>MEAN HOURLY DATA</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 24 mean hourly values - element 1. Missing value = 999999</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 24 mean hourly values - element 2. Missing value = 999999</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 24 mean hourly values - element 3. Missing value = 999999</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 24 mean hourly values - element 4. Missing value = 999999</td>
<td></td>
</tr>
<tr>
<td>5872</td>
<td><strong>DAILY MEANS</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 8 K-values. Missing value = 999</td>
<td></td>
</tr>
<tr>
<td>5888</td>
<td><strong>X INDICES</strong></td>
<td>RESERVED FOR EACH CONTRIBUTING INSTITUTION</td>
</tr>
</tbody>
</table>

See sections 4.3 and 4.3.1 for details
## APPENDIX C-1 (Cont’d)

### IAFV2.00 INTERMAGNET ARCHIVE FORMAT

**BINARY DATA STRUCTURE FORMAT - 32 BIT WORDS**

<table>
<thead>
<tr>
<th>WORD</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>HEADER</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Station ID</td>
<td>eg: BOU = HEX(20 42 4F 55)</td>
</tr>
<tr>
<td></td>
<td>- Year</td>
<td>Day Num</td>
</tr>
<tr>
<td></td>
<td>- Co-Latitude</td>
<td>(90° - Latitude) * 1000</td>
</tr>
<tr>
<td></td>
<td>- Longitude</td>
<td>East Longitude * 1000</td>
</tr>
<tr>
<td></td>
<td>- Elevation</td>
<td>elevation in meters above sea level</td>
</tr>
<tr>
<td></td>
<td>- Orientation</td>
<td>eg: XYZG = HEX(58 59 5A 47) (or HDZG)</td>
</tr>
<tr>
<td></td>
<td>- Source</td>
<td>eg: DMI = HEX(20 44 4D 49)</td>
</tr>
<tr>
<td></td>
<td>- Data Quality</td>
<td>eg: IMAG = HEX(49 4D 41 47)</td>
</tr>
<tr>
<td></td>
<td>- Instrumentation</td>
<td>eg: 750</td>
</tr>
<tr>
<td></td>
<td>- K9 value in nT</td>
<td>eg: 125</td>
</tr>
<tr>
<td></td>
<td>- Sampling rate (ms)</td>
<td>eg: XYZF, DIF, UVZ, HDZ, HDZF etc.</td>
</tr>
<tr>
<td></td>
<td>- Sensor orientation</td>
<td>eg: YYMM = 0806 (June 2008) HEX (30 38 30 36)</td>
</tr>
<tr>
<td></td>
<td>- Publication Date</td>
<td>HEX(02 00 00 00)version 2.00</td>
</tr>
<tr>
<td></td>
<td>- Reserved for future use</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 1440 mean minute values - element 1 (one day). Missing value = 999999</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 1440 mean minute values - element 2 (one day). Missing value = 999999</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 1440 mean minute values - element 3 (one day). Missing value = 999999</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 1440 mean minute values - element 4 (one day). Missing value = 999999</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5776</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 24 mean hourly values - element 1. Missing value = 999999</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 24 mean hourly values - element 2. Missing value = 999999</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 24 mean hourly values - element 3. Missing value = 999999</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 24 mean hourly values - element 4. Missing value = 999999</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5872</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Daily mean value element 1. Missing value = 999999</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Daily mean value element 2. Missing value = 999999</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Daily mean value element 3. Missing value = 999999</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Daily mean value element 4. Missing value = 999999</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5877</td>
<td>- 8 K-values. Missing value = 999</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5888</td>
<td></td>
<td>RESERVED FOR EACH CONTRIBUTING INSTITUTION</td>
</tr>
</tbody>
</table>

See sections 4.3 and 4.3.2 for details
### APPENDIX C-1 (Cont’d)

**IAFV1.10 INTERMAGNET ARCHIVE FORMAT**

**BINARY DATA STRUCTURE FORMAT - 32 BIT WORDS**

#### HEADER

<table>
<thead>
<tr>
<th>WORD</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Station ID</td>
<td>eg: BOU = HEX(20 42 4F 55)</td>
</tr>
<tr>
<td></td>
<td>Year</td>
<td>eg: 1989001; year 1989, day January 01</td>
</tr>
<tr>
<td></td>
<td>Co-Latitude</td>
<td>(90° - Latitude) * 1000</td>
</tr>
<tr>
<td></td>
<td>Longitude</td>
<td>East Longitude * 1000</td>
</tr>
<tr>
<td></td>
<td>Elevation</td>
<td>elevation in meters above sea level</td>
</tr>
<tr>
<td></td>
<td>Orientation</td>
<td>eg: XYZF = HEX(58 59 5A 46) (or HDZF)</td>
</tr>
<tr>
<td></td>
<td>Source</td>
<td>eg: DMI = HEX(20 44 4D 49)</td>
</tr>
<tr>
<td></td>
<td>D conversion</td>
<td>eg: H/3438*10000 where H=annual mean of H (set to 10000 for XYZF)</td>
</tr>
<tr>
<td></td>
<td>Data Quality</td>
<td>eg: LC(Linear Core) = HEX(20 20 4C 43) (or RC(Ring Core))</td>
</tr>
<tr>
<td></td>
<td>Instrumentation</td>
<td>eg: LC(Linear Core) = HEX(20 20 4C 43) (or RC(Ring Core))</td>
</tr>
<tr>
<td></td>
<td>K9 value in nT</td>
<td>eg: 750</td>
</tr>
<tr>
<td></td>
<td>Sampling rate (ms)</td>
<td>eg: XYZF, DIF, UVZ, HDZ, HDZF etc.</td>
</tr>
<tr>
<td></td>
<td>Sensor orientation</td>
<td>eg: YYMM = 0806 (June 2008)</td>
</tr>
<tr>
<td></td>
<td>Publication Date</td>
<td>eg: 0806 (June 2008)</td>
</tr>
<tr>
<td></td>
<td>IAF version number</td>
<td>HEX(01 00 00 00)</td>
</tr>
<tr>
<td></td>
<td>Reserved for future use</td>
<td></td>
</tr>
</tbody>
</table>

| 16   | 1440 mean minute values - element 1 (one day). Missing value = 999999 |
| 5776 | 24 mean hourly values - element 1. Missing value = 999999 |
| 5777 | 24 mean hourly values - element 2. Missing value = 999999 |
| 5872 | 24 mean hourly values - element 3. Missing value = 999999 |
| 5873 | 24 mean hourly values - element 4. Missing value = 999999 |
| 5876 | Daily mean value element 1. Missing value = 999999 |
| 5877 | Daily mean value element 2. Missing value = 999999 |
| 5878 | Daily mean value element 3. Missing value = 999999 |
|      | 8 digitally derived K-values. Missing value = 999 |

#### ONE MINUTE DATA

| 5776 | 1440 mean minute values - element 1 (one day). Missing value = 999999 |
| 5777 | 1440 mean minute values - element 2 (one day). Missing value = 999999 |
| 5872 | 1440 mean minute values - element 3 (one day). Missing value = 999999 |

#### MEAN HOURLY DATA

| 5876 | 24 mean hourly values - element 1. Missing value = 999999 |
| 5877 | 24 mean hourly values - element 2. Missing value = 999999 |
| 5878 | 24 mean hourly values - element 3. Missing value = 999999 |

#### DAILY MEANS

| 5877 | Daily mean value element 1. Missing value = 999999 |
| 5878 | Daily mean value element 2. Missing value = 999999 |
| 5879 | Daily mean value element 3. Missing value = 999999 |
| 5880 | Daily mean value element 4. Missing value = 999999 |

#### K INDICES

| 5888 | RESERVE FOR FUTURE USE = 0 |

See sections 4.3 and 4.3.3 for details.
### APPENDIX C-1 (Cont’d)

#### IAFV1.00 INTERMAGNET ARCHIVE FORMAT

**BINARY DATA STRUCTURE FORMAT-32 BIT WORDS**

<table>
<thead>
<tr>
<th>WORD</th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Header</td>
<td>Station ID eg: BOU = HEX(20 42 4F 55)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Co-Latitude</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Longitude</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Elevation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Orientation eg: DMI = HEX(20 44 4D 49)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Source</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-D conversion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Data Quality eg: LC(Linear Core) = HEX(20 20 4C 43) (or RC(Ring Core))</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Instrumentation eg: XYZF = HEX(58 59 5A 46) (or HDZF)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Sensor orientation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Reserved for future use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-IAF version number</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Reserved for each contributing institution</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>1440 mean minute values - element 1 (one day). Missing value = 999999</td>
</tr>
<tr>
<td>5776</td>
<td></td>
<td>24 mean hourly values - element 1. Missing value = 999999</td>
</tr>
<tr>
<td>5777</td>
<td></td>
<td>24 mean hourly values - element 2. Missing value = 999999</td>
</tr>
<tr>
<td>5778</td>
<td></td>
<td>24 mean hourly values - element 3. Missing value = 999999</td>
</tr>
<tr>
<td>5872</td>
<td></td>
<td>24 mean hourly values - element 4. Missing value = 999999</td>
</tr>
<tr>
<td>5873</td>
<td></td>
<td>8 digitally derived K-values. Missing value = 999</td>
</tr>
<tr>
<td>5876</td>
<td></td>
<td>daily mean value element 1. Missing value = 999999</td>
</tr>
<tr>
<td>5877</td>
<td></td>
<td>daily mean value element 2. Missing value = 999999</td>
</tr>
<tr>
<td>5878</td>
<td></td>
<td>daily mean value element 3. Missing value = 999999</td>
</tr>
<tr>
<td>5888</td>
<td></td>
<td>daily mean value element 4. Missing value = 999999</td>
</tr>
</tbody>
</table>

- See section 4.3 and 4.3.4 for details
APPENDIX C-2
INTERMAGNET DVD/CD-ROM DIRECTORY STRUCTURE
APPENDIX C-3

IYFV1.02 INTERMAGNET DVD/CD-ROM FORMAT FOR YEARMEAN FILE

Magnetic data with 1nT or 0.1 min of arc resolution are organized on a year file basis. One file contains all annual mean values of the geomagnetic field components that are available from the observatory.

File name: "YEARMEAN" and the three-letter observatory ID code as an extension. eg: YEARMEAN.BOU for Boulder.

Each file may have from 1 to 3 tables containing annual mean values. The file must contain a table of annual means for ALL-DAYS, but may also contain tables of annual means for QUIET-DAYS and DISTURBED-DAYS.

Description of the header block

The header contains information on observatory name, ID-code, Colatitude, Longitude and Elevation. It further contains the headers for each data columns.

eg: The header for Wingst is:

ANNUAL MEAN VALUES

WINGST WNG, GERMANY

COLATITUDE: 36.257 LONGITUDE: 9.073 E ELEVATION: 50 m

YEAR D I H X Y Z F * ELE Note
deg min deg min nT nT nT nT nT

Description of data space (75 characters per line including CrLf)

All data fields are right-justified. The field width must be maintained, either by zero-filling or space-filling. The '+' sign for positive values is optional.

_YYYY.yyy_DDD_dd.d_III_ii.i_HHHHHH_XXXXXX_YYYYYY_ZZZZZZ_FFFFFF_A_EEEE_NNNCrLf
....

YYYY.yyy : Epoch is given with 3 decimals.
DDD_dd.d : Declination is given in degrees and decimal minutes of arc.
III_ii.i : Inclination is given in degrees and decimal minutes of arc.
HHHHHH : H-component is given in nT.
XXXXXX : X-component is given in nT.
YYYYYY : Y-component is given in nT.
ZZZZZZ : Z-component is given in nT.
FFFFFF : F-component is given in nT.
A : Type of annual means. May be "A"ll, "Q"uiet, "D"isturbed, "I"ncomplete" or "J"ump. The "J" is not an annual mean value, but indicates a jump in the observatory recordings, which should be described in a note.
EEE : recorded elements. eg:"XYZF" or "HDZF".
NNN : Note number.
CrLf : Indicates a Carriage return Line feed.

- Missing angular values must be coded as three 9 digits, a space, two 9 digits, a dot and one 9 digit: 999 99.9
- Missing component values must be coded as six 9 digits: 999999
- Angular values are written as degrees and minutes. Values may be written in the range 0 to 360 or -180 to 180. Observatories may choose which range to use. Negative values must always have the minus sign before the degree field, never before the minute field (including values between 0 and -1 degrees, for example "-0.59" means a value of minus zero degrees fifty nine minutes). This applies to all types of records, including jump records.
APPENDIX C-3 (Cont’d)

IYFV1.02 INTERMAGNET DVD/CD-ROM FORMAT FOR YEARMEAN FILE

Description of the footer

At the end of the file is added a footer describing the data. The footer contains notes on jumps, incomplete data sets etc. A sample footer looks like this:

* A = All days
* Q = Quiet Days
* D = Disturbed Days
* I = Incomplete
* J = Jump: jump value = old site value - new site value

ELE = Recorded elements from which the annual means were derived. If an independent total field measurement is not made at an observatory, this field should not include an 'F' code. For example, an observatory using a three component fluxgate with one horizontal sensor aligned along the magnetic meridian and a proton magnetometer would put 'HDZF' in this field. An observatory using only the fluxgate would put 'HDZ'.

Notes: 1. The jump in the values from 1988 to 1989 is due to establishment of a new absolute pillar during 1988.
2. The jump in the values from 1993 to 1994 is due to a change in the difference delta-F between the PPM pillar and the absolute pillar. The change happened between spring 1989 and autumn 1993. Why and when is unknown.

Sample of a yearmean file

ANNUAL MEAN VALUES

NARSARSUAQ, NAQ, GREENLAND

<table>
<thead>
<tr>
<th>YEAR</th>
<th>D</th>
<th>I</th>
<th>H</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
<th>F</th>
<th>ELE</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Deg. '</td>
<td>'</td>
<td>nT</td>
<td>nT</td>
<td>nT</td>
<td>nT</td>
<td>nT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1983.5</td>
<td>326 41.6</td>
<td>77 15.8</td>
<td>12152</td>
<td>10156</td>
<td>-6673</td>
<td>53764</td>
<td>55120</td>
<td>A</td>
<td>DHZ</td>
</tr>
<tr>
<td>1984.5</td>
<td>326 55.7</td>
<td>77 14.3</td>
<td>12171</td>
<td>10199</td>
<td>-6642</td>
<td>53736</td>
<td>55097</td>
<td>A</td>
<td>DHZ</td>
</tr>
<tr>
<td>1985.5</td>
<td>327 11.1</td>
<td>77 12.9</td>
<td>12187</td>
<td>10242</td>
<td>-6604</td>
<td>53706</td>
<td>55071</td>
<td>A</td>
<td>DHZ</td>
</tr>
<tr>
<td>1986.5</td>
<td>327 26.8</td>
<td>77 13.7</td>
<td>12201</td>
<td>10284</td>
<td>-6565</td>
<td>53679</td>
<td>55048</td>
<td>A</td>
<td>DHZ</td>
</tr>
<tr>
<td>1987.5</td>
<td>327 44.5</td>
<td>77 09.9</td>
<td>12223</td>
<td>10336</td>
<td>-6524</td>
<td>53647</td>
<td>55022</td>
<td>A</td>
<td>DHZ</td>
</tr>
<tr>
<td>1988.5</td>
<td>328 00.5</td>
<td>77 09.0</td>
<td>12235</td>
<td>10377</td>
<td>-6482</td>
<td>53633</td>
<td>55011</td>
<td>A</td>
<td>DHZ</td>
</tr>
<tr>
<td>1989.0</td>
<td>0 02.6</td>
<td>0 00.7</td>
<td>-4</td>
<td>2</td>
<td>10</td>
<td>30</td>
<td>28</td>
<td>J</td>
<td>DHZ</td>
</tr>
<tr>
<td>1989.5</td>
<td>328 13.8</td>
<td>77 07.2</td>
<td>12254</td>
<td>10418</td>
<td>-6452</td>
<td>53592</td>
<td>54975</td>
<td>A</td>
<td>DHZ</td>
</tr>
<tr>
<td>1990.5</td>
<td>328 29.9</td>
<td>77 05.9</td>
<td>12271</td>
<td>10463</td>
<td>-6412</td>
<td>53571</td>
<td>54959</td>
<td>A</td>
<td>DHZ</td>
</tr>
<tr>
<td>1991.5</td>
<td>328 45.6</td>
<td>77 04.9</td>
<td>12284</td>
<td>10503</td>
<td>-6371</td>
<td>53555</td>
<td>54946</td>
<td>A</td>
<td>DHZ</td>
</tr>
<tr>
<td>1992.5</td>
<td>329 01.3</td>
<td>77 03.4</td>
<td>12302</td>
<td>10547</td>
<td>-6332</td>
<td>53525</td>
<td>54920</td>
<td>A</td>
<td>DHZ</td>
</tr>
<tr>
<td>1993.5</td>
<td>329 17.9</td>
<td>77 01.6</td>
<td>12323</td>
<td>10596</td>
<td>-6292</td>
<td>53495</td>
<td>54896</td>
<td>A</td>
<td>DHZ</td>
</tr>
<tr>
<td>1994.0</td>
<td>0 00.0</td>
<td>0 00.0</td>
<td>-1</td>
<td>-1</td>
<td>0</td>
<td>-2</td>
<td>-3</td>
<td>J</td>
<td>DHZ</td>
</tr>
<tr>
<td>1994.5</td>
<td>329 34.3</td>
<td>77 00.7</td>
<td>12335</td>
<td>10636</td>
<td>-6247</td>
<td>53476</td>
<td>54880</td>
<td>A</td>
<td>DHZ</td>
</tr>
<tr>
<td>1995.5</td>
<td>329 53.6</td>
<td>76 58.3</td>
<td>12366</td>
<td>10698</td>
<td>-6203</td>
<td>53444</td>
<td>54856</td>
<td>A</td>
<td>DHZ</td>
</tr>
<tr>
<td>1996.5</td>
<td>330 13.6</td>
<td>76 56.0</td>
<td>12395</td>
<td>10759</td>
<td>-6155</td>
<td>53409</td>
<td>54828</td>
<td>A</td>
<td>DHZ</td>
</tr>
<tr>
<td>1997.5</td>
<td>330 33.9</td>
<td>76 54.0</td>
<td>12423</td>
<td>10819</td>
<td>-6105</td>
<td>53381</td>
<td>54807</td>
<td>A</td>
<td>DHZ</td>
</tr>
<tr>
<td>1998.5</td>
<td>330 55.6</td>
<td>76 52.2</td>
<td>12446</td>
<td>10878</td>
<td>-6048</td>
<td>53361</td>
<td>54793</td>
<td>A</td>
<td>DHZ</td>
</tr>
<tr>
<td>1999.5</td>
<td>331 17.3</td>
<td>76 50.2</td>
<td>12473</td>
<td>10939</td>
<td>-5992</td>
<td>53332</td>
<td>54771</td>
<td>A</td>
<td>DHZ</td>
</tr>
<tr>
<td>2000.5</td>
<td>331 39.0</td>
<td>76 48.4</td>
<td>12497</td>
<td>10998</td>
<td>-5934</td>
<td>53311</td>
<td>54756</td>
<td>A</td>
<td>DHZ</td>
</tr>
<tr>
<td>2001.5</td>
<td>332 01.3</td>
<td>76 46.1</td>
<td>12527</td>
<td>11063</td>
<td>-5877</td>
<td>53278</td>
<td>54731</td>
<td>A</td>
<td>DHZ</td>
</tr>
<tr>
<td>2002.5</td>
<td>332 23.6</td>
<td>76 44.2</td>
<td>12553</td>
<td>11124</td>
<td>-5817</td>
<td>53254</td>
<td>54714</td>
<td>A</td>
<td>DHZ</td>
</tr>
<tr>
<td>2003.5</td>
<td>332 45.2</td>
<td>76 43.3</td>
<td>12564</td>
<td>11170</td>
<td>-5752</td>
<td>53237</td>
<td>54699</td>
<td>A</td>
<td>DHZ</td>
</tr>
<tr>
<td>2004.5</td>
<td>333 07.8</td>
<td>76 40.5</td>
<td>12600</td>
<td>11240</td>
<td>-5695</td>
<td>53202</td>
<td>54674</td>
<td>A</td>
<td>DHZ</td>
</tr>
<tr>
<td>2005.5</td>
<td>333 29.3</td>
<td>76 38.7</td>
<td>12624</td>
<td>11296</td>
<td>-5635</td>
<td>53176</td>
<td>54654</td>
<td>A</td>
<td>DHZ</td>
</tr>
<tr>
<td>YEAR</td>
<td>D</td>
<td>I</td>
<td>H</td>
<td>X</td>
<td>Y</td>
<td>Z</td>
<td>F</td>
<td>* ELE</td>
<td>Note</td>
</tr>
<tr>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-----</td>
<td>-------</td>
<td>------</td>
</tr>
<tr>
<td></td>
<td>Deg.</td>
<td>'</td>
<td>Deg.</td>
<td>'</td>
<td>nT</td>
<td>nT</td>
<td>nT</td>
<td>nT</td>
<td>nT</td>
</tr>
<tr>
<td>1983.500</td>
<td>326 42.3</td>
<td>77 15.1</td>
<td>12164 10167</td>
<td>-6677</td>
<td>53765</td>
<td>55124</td>
<td>Q</td>
<td>DHZ</td>
<td></td>
</tr>
<tr>
<td>1984.500</td>
<td>326 56.3</td>
<td>77 13.3</td>
<td>12186 10213</td>
<td>-6648</td>
<td>53734</td>
<td>55098</td>
<td>Q</td>
<td>DHZ</td>
<td></td>
</tr>
<tr>
<td>1985.500</td>
<td>327 25.6</td>
<td>77 12.0</td>
<td>12202 10256</td>
<td>-6611</td>
<td>53704</td>
<td>55073</td>
<td>Q</td>
<td>DHZ</td>
<td></td>
</tr>
<tr>
<td>1986.500</td>
<td>327 27.4</td>
<td>77 10.8</td>
<td>12215 10297</td>
<td>-6571</td>
<td>53676</td>
<td>55048</td>
<td>Q</td>
<td>DHZ</td>
<td></td>
</tr>
<tr>
<td>1987.500</td>
<td>327 44.9</td>
<td>77 09.4</td>
<td>12232 10345</td>
<td>-6527</td>
<td>53648</td>
<td>55025</td>
<td>Q</td>
<td>DHZ</td>
<td></td>
</tr>
<tr>
<td>1988.500</td>
<td>328 00.8</td>
<td>77 08.2</td>
<td>12246 10387</td>
<td>-6487</td>
<td>53631</td>
<td>55011</td>
<td>Q</td>
<td>DHZ</td>
<td></td>
</tr>
<tr>
<td>1989.000</td>
<td>328 42.6</td>
<td>77 07.0</td>
<td></td>
<td>-4</td>
<td>2</td>
<td>10</td>
<td>30</td>
<td>-28</td>
<td>J</td>
</tr>
<tr>
<td>1989.500</td>
<td>328 14.4</td>
<td>77 06.6</td>
<td>12243 10427</td>
<td>-6455</td>
<td>53617</td>
<td>54976</td>
<td>Q</td>
<td>DHZ</td>
<td></td>
</tr>
<tr>
<td>1990.500</td>
<td>328 30.0</td>
<td>77 05.3</td>
<td>12279 10470</td>
<td>-6416</td>
<td>53567</td>
<td>54956</td>
<td>Q</td>
<td>DHZ</td>
<td></td>
</tr>
<tr>
<td>1991.500</td>
<td>328 46.1</td>
<td>77 04.0</td>
<td>12297 10515</td>
<td>-6376</td>
<td>53551</td>
<td>54945</td>
<td>Q</td>
<td>DHZ</td>
<td></td>
</tr>
<tr>
<td>1992.500</td>
<td>329 01.6</td>
<td>77 02.7</td>
<td>12312 10556</td>
<td>-6336</td>
<td>53521</td>
<td>54919</td>
<td>Q</td>
<td>DHZ</td>
<td></td>
</tr>
<tr>
<td>1993.500</td>
<td>329 18.2</td>
<td>77 00.9</td>
<td>12335 10607</td>
<td>-6297</td>
<td>53491</td>
<td>54895</td>
<td>Q</td>
<td>DHZ</td>
<td></td>
</tr>
<tr>
<td>1994.000</td>
<td>329 35.4</td>
<td>76 59.2</td>
<td>12357 10657</td>
<td>-6255</td>
<td>53470</td>
<td>54879</td>
<td>Q</td>
<td>DHZ</td>
<td></td>
</tr>
<tr>
<td>1994.500</td>
<td>330 35.4</td>
<td>76 58.3</td>
<td>12380 10697</td>
<td>-6216</td>
<td>53443</td>
<td>54868</td>
<td>Q</td>
<td>DHZ</td>
<td></td>
</tr>
<tr>
<td>1995.500</td>
<td>330 10.1</td>
<td>76 57.1</td>
<td>12403 10742</td>
<td>-5987</td>
<td>53407</td>
<td>54857</td>
<td>Q</td>
<td>DHZ</td>
<td></td>
</tr>
<tr>
<td>1996.500</td>
<td>330 10.1</td>
<td>76 56.0</td>
<td>12426 10788</td>
<td>-5948</td>
<td>53373</td>
<td>54846</td>
<td>Q</td>
<td>DHZ</td>
<td></td>
</tr>
<tr>
<td>1997.500</td>
<td>330 10.1</td>
<td>76 55.0</td>
<td>12449 10834</td>
<td>-5908</td>
<td>53343</td>
<td>54835</td>
<td>Q</td>
<td>DHZ</td>
<td></td>
</tr>
<tr>
<td>1998.500</td>
<td>330 10.1</td>
<td>76 54.0</td>
<td>12472 10881</td>
<td>-5868</td>
<td>53313</td>
<td>54824</td>
<td>Q</td>
<td>DHZ</td>
<td></td>
</tr>
<tr>
<td>1999.500</td>
<td>330 10.1</td>
<td>76 53.0</td>
<td>12494 10928</td>
<td>-5828</td>
<td>53283</td>
<td>54813</td>
<td>Q</td>
<td>DHZ</td>
<td></td>
</tr>
<tr>
<td>2000.500</td>
<td>330 10.1</td>
<td>76 52.0</td>
<td>12517 10975</td>
<td>-5788</td>
<td>53253</td>
<td>54802</td>
<td>Q</td>
<td>DHZ</td>
<td></td>
</tr>
<tr>
<td>2001.500</td>
<td>330 10.1</td>
<td>76 51.0</td>
<td>12540 11022</td>
<td>-5748</td>
<td>53223</td>
<td>54791</td>
<td>Q</td>
<td>DHZ</td>
<td></td>
</tr>
<tr>
<td>2002.500</td>
<td>330 10.1</td>
<td>76 50.0</td>
<td>12563 11069</td>
<td>-5708</td>
<td>53193</td>
<td>54780</td>
<td>Q</td>
<td>DHZ</td>
<td></td>
</tr>
<tr>
<td>2003.500</td>
<td>330 10.1</td>
<td>76 49.0</td>
<td>12586 11116</td>
<td>-5668</td>
<td>53163</td>
<td>54769</td>
<td>Q</td>
<td>DHZ</td>
<td></td>
</tr>
<tr>
<td>2004.500</td>
<td>330 10.1</td>
<td>76 48.0</td>
<td>12609 11163</td>
<td>-5628</td>
<td>53133</td>
<td>54758</td>
<td>Q</td>
<td>DHZ</td>
<td></td>
</tr>
<tr>
<td>2005.500</td>
<td>330 10.1</td>
<td>76 47.0</td>
<td>12632 11210</td>
<td>-5588</td>
<td>53103</td>
<td>54747</td>
<td>Q</td>
<td>DHZ</td>
<td></td>
</tr>
</tbody>
</table>

Notes: 1. The jump in the values from 1988 to 1989 is due to establishment of a new absolute pillar during 1988.
2. The jump in the values from 1993 to 1994 is due to a change in the difference delta-F between the PPM pillar and the absolute pillar. The change happened between spring 1989 and autumn 1993. Why and when is unknown.

Sample of missing values

<table>
<thead>
<tr>
<th>YEAR</th>
<th>D</th>
<th>I</th>
<th>H</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
<th>F</th>
<th>* ELE</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Deg.</td>
<td>'</td>
<td>Deg.</td>
<td>'</td>
<td>nT</td>
<td>nT</td>
<td>nT</td>
<td>nT</td>
<td>nT</td>
</tr>
<tr>
<td>1983.500</td>
<td>999 99.9</td>
<td>999 99.9</td>
<td>999999</td>
<td>999999</td>
<td>999999</td>
<td>999999</td>
<td>999999</td>
<td>A</td>
<td>DHZ</td>
</tr>
<tr>
<td>1984.500</td>
<td>999 99.9</td>
<td>77 14.3</td>
<td>12171 999999</td>
<td>-6642</td>
<td>53736</td>
<td>55097</td>
<td>A</td>
<td>DHZ</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX D-1

INTERMAGNET EXECUTIVE COUNCIL ADDRESSES

Arnaud Chulliat
Institut de Physique du Globe de Paris
Observatoires magnétiques - Bureau 111
1 rue Jussieu
75238 Paris Cedex 05
FRANCE
TEL: 33 (0) 1-83-95-74-90
FAX: 33 (0) 1-83-95-77-09
INTERNET: chulliat@ipgp.fr

David J. Kerridge
British Geological Survey
West Mains Road
Edinburgh EH9 3LA
UK
TEL: 44-131-667-1000
FAX: 44-131-668-4368
INTERNET: D.Kerridge@bgs.ac.uk

Jeffrey J. Love
U.S. Geological Survey
Box 25046 MS 966
Denver Federal Center
Denver, Colorado 80225
USA
TEL: 1-303-273-8540
FAX: 1-303-273-8450
INTERNET: jlove@usgs.gov

David Boteler
Geological Survey of Canada
Geophysics Division
7 Observatory Crescent
Ottawa Ontario K1A OY3
CANADA
TEL: 1-613-837-2035
FAX: 1-613-824-9803
INTERNET: dboteler@nrcan.gc.ca
APPENDIX D-1 (Cont'd)

INTERMAGNET OPERATIONS COMMITTEE ADDRESSES

Peter Crosthwaite
Geoscience Australia
Cnr Jerrabomberra Avenue and Hindmarsh Drive Symonston
GPO Box 378
Canberra ACT 2601
Australia
TEL: 61-2-6249-9321
FAX: 61-2-6249-9986
INTERNET: peter.crosthwaite@ga.gov.au

Simon M. Flower
British Geological Survey
Murchison House
West Mains Road
Edinburgh EH9 3LA
UK
TEL: 44-131-667-1000
FAX: 44-131-667-1877
INTERNET: s.flower@bgs.ac.uk

Hans-Joachim Linthe
GFZ Potsdam, Adolf-Schmidt-Observatory
Lindenstr. 7
D-14823 Niemegk
Germany
TEL: 49-33843-62414
FAX: 49-33843-62423
INTERNET: linthe@gfz-potsdam.de

Jürgen Matzka
Technical University of Denmark
National Space Institute
Elektrovej
Building 327
DK-2800 Kgs. Lyngby
Denmark
TEL: 45-4525-9706
INTERNET: jrgm@space.dtu.dk

Virginie Maury
Institut de Physique du Globe de Paris
Observatoires magnétiques - Bureau 110s
1, rue Jussieu
75238 Paris Cedex 05
FRANCE
TEL: 33 (0) 1-83-95-77-80
FAX: 33 (0) 1-71-93-77-09
INTERNET: vmaury@ipgp.fr

Masahito Nosé
World Data Center for Geomagnetism, Kyoto
Data Analysis Center for Geomagnetism
and Space Magnetism
Oiwake-cho, Kitashirakawa, Sakyoku
Kyoto 606-8502
Japan
TEL: 075-753-3959
FAX: 075-722-7884
INTERNET: nosa@kugi.kyoto-u.ac.jp

Jean L. Rasson
Institut Royal Météorologique de Belgique
Centre de Physique du Globe
Observatoire Magnétique
B-5670 Dourbes
BELGIQUE
TEL: 32-60-395442
FAX: 32-60-395423
INTERNET: jr@oma.be

Jan Reda
Institute of Geophysics PAS
Central Geophysical Observatory
05-622 Belsk
Poland
TEL: 48-48-664-2056
FAX: 48-48-661-1373
INTERNET: jreda@igf.edu.pl
### INTERMAGNET OPERATIONS COMMITTEE ADDRESSES

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Address</th>
<th>Phone</th>
<th>Fax</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benoit J. St-Louis</td>
<td>Geological Survey of Canada</td>
<td>7 Observatory Crescent, Ottawa, Ontario</td>
<td>1-613-837-4241</td>
<td>1-613-824-9803</td>
<td><a href="mailto:stlouis@geolab.nrcan.gc.ca">stlouis@geolab.nrcan.gc.ca</a></td>
</tr>
<tr>
<td>Christopher W. Turbitt</td>
<td>British Geological Survey</td>
<td>Murchison House, Edinburgh EH9 3LA, UK</td>
<td>44-131-667-1000</td>
<td>44-131-667-1877</td>
<td><a href="mailto:c.turbitt@bgs.ac.uk">c.turbitt@bgs.ac.uk</a></td>
</tr>
</tbody>
</table>
APPENDIX E-1

INTERMAGNET FORMAT IMFV2.83

The INTERMAGNET satellite data transmission format IMFV2.83 defines the structure of 126 bytes of magnetic observatory information. METEOSAT users, who must transmit once per hour, will send five 12-minute IMFV2.83 data blocks. GOES users transmit at 12-minute intervals one IMFV2.83 data block encoded in NESS-BINARY (189 bytes). The order of transmission to the satellite will be in byte sequence low-byte first, then high-byte. Refer to Appendix E-2 for satellite coding examples.

### HEADER 12 BYTES

<table>
<thead>
<tr>
<th>Field</th>
<th>Byte #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time stamp of the first sample</td>
<td></td>
</tr>
<tr>
<td>Day (1-365/366)</td>
<td>12 Bits</td>
</tr>
<tr>
<td>Minute of the day (0 - 1439)</td>
<td>12 Bits</td>
</tr>
<tr>
<td>Offset for C1</td>
<td>8 Bits</td>
</tr>
<tr>
<td>Offset for C2</td>
<td>8 Bits</td>
</tr>
<tr>
<td>Offset for C3</td>
<td>8 Bits</td>
</tr>
<tr>
<td>Offset for C4</td>
<td>8 Bits</td>
</tr>
<tr>
<td>Flags #1</td>
<td>8 Bits</td>
</tr>
<tr>
<td>Flags #2</td>
<td>8 Bits</td>
</tr>
<tr>
<td>Identification:</td>
<td></td>
</tr>
<tr>
<td>Colatitude in 1/10 degrees (0 - 1800)</td>
<td>12 Bits</td>
</tr>
<tr>
<td>East Longitude in 1/10 degrees (0 - 3600)</td>
<td>12 Bits</td>
</tr>
</tbody>
</table>

### FREE SPACE 8 BYTES

### REFERENCE MEASUREMENT (RM) SPACE OR FREE SPACE 10 BYTES

### MINUTE VALUES 96 BYTES

| C1 for sample 1                            | 16 Bits|
| C2 for sample 1                            | 16 Bits|
| C3 for sample 1                            | 16 Bits|
| .                                          |        |
| .                                          |        |
| C1 for sample 12                           | 16 Bits|
| C2 for sample 12                           | 16 Bits|
| C3 for sample 12                           | 16 Bits|
| C4 for sample 12                           | 16 Bits|

* See Header Encoding
APPENDIX E-1 (Cont'd)

**FLAGS #1**

MSB (8) & (7) Orientation code

<table>
<thead>
<tr>
<th>Orientation Code</th>
<th>Component 1</th>
<th>Component 2</th>
<th>Component 3</th>
<th>Component 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>X</td>
<td>Y</td>
<td>Z</td>
<td>F</td>
</tr>
<tr>
<td>1</td>
<td>H</td>
<td>D</td>
<td>Z</td>
<td>F</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>D</td>
<td>I</td>
<td>F</td>
</tr>
<tr>
<td>3</td>
<td>.</td>
<td>.</td>
<td>(OTHER)</td>
<td>.</td>
</tr>
</tbody>
</table>

(6) Scale factor for X or H
(5) Scale factor for Y or D
(4) Scale factor for Z or I
(3) Scale factor for F
(2) Filtering 0: INTERMAGNET approved filtering
1: non-approved filtering
See INTERMAGNET terminology "filtering"

(1) Alert capability -- The IMO has the ability to detect magnetic events if the flag is set to 1.
0: not active
1: active

**FLAGS #2**

MSB (8) Sudden storm commencement detected

(7) Storm in progress -- A storm is in progress if the level of magnetic activity is equivalent to K>4 for past one-hour period. The flag will be reset to zero when the equivalent level of activity drops to K<4.

(6) 0: No Reference Measurement (RM) capability bytes 13-30 are user free space
1: Base Reference Measurement data available in bytes 21-30. Bytes' 13-20 are user free space.

(5) (4) (3) (2) (1) Free (user defined)
APPENDIX E-1 (Cont'd)

IMFV2.83 HEADER ENCODING

In IMFV2.83 format, the time stamp and site identification code are encoded in 3-byte strings formed from two 12-bit fields combined as described below:

<table>
<thead>
<tr>
<th>Time Stamp Input</th>
<th>Encoded Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Least sig. 8 bits of day</td>
<td>Byte 1</td>
</tr>
<tr>
<td>Most sig. 4 bits of day</td>
<td>Byte 2, four least sig. bits</td>
</tr>
<tr>
<td>Least sig. 4 bits of minute</td>
<td>Byte 2, four most sig. bits</td>
</tr>
<tr>
<td>Most sig. 8 bits of minute</td>
<td>Byte 3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Site Identification Code Input</th>
<th>Encoded Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Least sig. 8 bits of colatitude</td>
<td>Byte 10</td>
</tr>
<tr>
<td>Most sig. 4 bits of colatitude</td>
<td>Byte 11, four least sig. bits</td>
</tr>
<tr>
<td>Least sig. 4 bits of east longitude</td>
<td>Byte 11, four most sig. bits</td>
</tr>
<tr>
<td>Most sig. 8 bits of east longitude</td>
<td>Byte 12</td>
</tr>
</tbody>
</table>

Example:
The time stamp for day 30, minute 684 would be encoded as:

<table>
<thead>
<tr>
<th>Input fields</th>
<th>Output Encoded field</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 30 0 1 E (first item)</td>
<td>1ECO2A</td>
</tr>
<tr>
<td>Minute 684 2 A C (second item)</td>
<td>1ECO2A</td>
</tr>
</tbody>
</table>

IMFV2.83 DATA VALUE ENCODING

Constraints on the bandwidth of a GOES satellite communications channel dictate a maximum transmission block of 126 bytes of data once every 12 minutes from an INTERMAGNET Magnetic Observatory (IMO). To conserve bytes, each measurement of a magnetic component is represented using only 2 bytes which, upon reception, are interpreted together with header information to produce a resultant 3-byte representation at the Geomagnetic Information Node (GIN). All magnetic field values in this encoding description are expressed in tenths of nanoTeslas (tnT) unless otherwise noted. The resolution of the measurements is 1 tnT and so a 16-bit representation allows a $2^{16} = 65536$ tnT (6553.6 nT) dynamic range within a 12-minute IMFV2.83 block. This is inadequate to accommodate magnetic storms at some locations, and so the encoding scheme produces measurements at reduced sensitivity when extremely large excursions are present. The INTERMAGNET data encoding produces an Offset (OFF) value and a Scale Factor (SF) flag bit for each component, as well as the encoded individual minute values (see diagram at end of appendix). The OFF and SF apply to all measurements of a component within an IMFV2.83 data block.

We define the terms used in encoding as follows:

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data(i)</td>
<td>Set of minute values measured in tnT</td>
</tr>
<tr>
<td>$D_{pos}(i)$</td>
<td>Minute values shifted by $1048576$ to be always positive</td>
</tr>
<tr>
<td>$D_{max}$</td>
<td>Largest $D_{pos}(i)$ of a given component in IMFV2.83 block</td>
</tr>
<tr>
<td>$D_{min}$</td>
<td>Smallest $D_{pos}(i)$ of a given component in IMFV2.83 block</td>
</tr>
<tr>
<td>OFF</td>
<td>Offset value</td>
</tr>
<tr>
<td>BF</td>
<td>Bias Factor = 8192</td>
</tr>
<tr>
<td>SM</td>
<td>Scale Multiplier for sensitivity of encoded data</td>
</tr>
<tr>
<td>SF</td>
<td>Scale Factor flag for sensitivity of encoded data</td>
</tr>
<tr>
<td>E(i)</td>
<td>Set of encoded minute values</td>
</tr>
</tbody>
</table>
Numbers used in this encoding algorithm have been chosen to permit simple binary arithmetic operations:

\[
\begin{align*}
8192 &= 2^{13} \\
57344 &= 2^{16} - 2^{13} \\
1048576 &= 2^{20} \\
2097151 &= 2^{21} - 1
\end{align*}
\]

Encoding of a 12-minute IMFV2.83 data block begins by adding a constant 1048576 tnT to the minute values Data(i) to produce a new data set \(D_{pos}(i)\) whose values are always positive.

\[
D_{pos}(i) = Data(i) + 1048576 \quad (1)
\]

The limiting values of these \(D_{pos}(i)\) are 0 and 2097151 tnT.

An Offset value (OFF) is next computed from the \(D_{pos}(i)\) for each component by using the minimum value of the component, \(D_{min}\).

\[
OFF = \text{INT} \left( \frac{D_{min}}{BF} \right) \quad (2)
\]

where INT means the truncated integer after the division. The OFF value for each component may be anywhere in the range of 0 to 255 and the OFF values for the four components are stored in bytes 4,5,6,7 of the header for use in decoding the data after reception at a GIN.

A Scale Multiplier (SM) for each component is now computed:

\[
SM = \text{INT} \left( \frac{D_{max} - OFF \cdot BF}{57344} \right) + 1 \quad (3)
\]

The encoding algorithm produces an SM whose value is governed by the range of \(D_{pos}(i)\) within a data block. In this application to format IMFV2.83, however, SM can in practice be limited to values of either 1 or 2. Format IMFV2.83 reserves only one flag bit per component for storing scale information.

These flags are bits 6,5,4,3 of byte 8 in the header, labelled Scale Factor (SF). Flag bit SF=0 represents SM=1, where the encoded data are considered at normal sensitivity (1 tnT/bit). At SM=1, the dynamic range available in the data block is at least 49152 tnT (= 57344-BF) and at most 57344 tnT, depending upon where the \(D_{min}\) value sits relative to the quantity OFF*BF. Flag bit SF=1 represents SM=2, where the encoded data are considered as half sensitivity (2 tnT/bit). At SM=2, the dynamic range in the data block is at least 106496 tnT (= 2*57344-BF) and at most 114688 tnT (= 2*57344) depending again upon where \(D_{min}\) is relative to the quantity OFF*BF.

Encoded data values are now computed as:

\[
E(i) = \text{INT} \left( \frac{D_{pos}(i) - OFF \cdot BF}{SM} \right) \quad (4)
\]

and are stored in bytes 31 to 126. Upon reception at the GIN, encoded data are reconstituted using the expression:

\[
Data(i) = E(i) \cdot SM + OFF \cdot BF - 1048576 \quad (5)
\]

This reconstitution is exact for SM=1 but rounded down by no more than 2 tnT on those infrequent occasions when SM=2.

In summary, the expressions defining each of the encoding and reconstitution steps are:

\[
\begin{align*}
D_{pos}(i) &= Data(i) + 1048576 \quad (1) \\
OFF &= \text{INT} \left( \frac{D_{min}}{BF} \right) \quad (BF=8192) \quad (2) \\
SM &= \text{INT} \left( \frac{D_{max} - OFF \cdot BF}{57344} \right) + 1 \quad (3) \\
E(i) &= \text{INT} \left( \frac{D_{pos}(i) - OFF \cdot BF}{SM} \right) \quad (4) \\
Data(i) &= E(i) \cdot SM + OFF \cdot BF - 1048576 \quad (5)
\end{align*}
\]

Scale Factor flags are set as follows:

<table>
<thead>
<tr>
<th>SF</th>
<th>SM</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

**NOTE:** E(i) set to 65535 (FFFF hex) indicates missing or invalid data.
### IMFV2.83 DATA VALUE ENCODING

<table>
<thead>
<tr>
<th>Minute</th>
<th>Shifted Data</th>
<th>Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data (i)</td>
<td>D_{pos} (i)</td>
<td>OFF</td>
</tr>
<tr>
<td>(tnT)</td>
<td>2097151</td>
<td>16</td>
</tr>
<tr>
<td>255</td>
<td>2088960</td>
<td>.</td>
</tr>
<tr>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>1048576</td>
<td>1048576</td>
<td>8</td>
</tr>
<tr>
<td>7</td>
<td>57344</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>49152</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>40960</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>32768</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>24576</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>16384</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>8192</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Note:**
- Span for SM=1
  - 57344
APPENDIX E-2

SATELLITE CODING EXAMPLES

CODING EXAMPLE FOR GOES SATELLITE

Each block of 126 bytes in IMFV2.83 must be encoded in 189 NESS-BINARY bytes (NESSbytes). NESS-BINARY breaks each pair of source bytes (word) into 3 NESSbytes. If the bits of the source word are B15-B0 with B15 the most significant, then these are placed right-justified in NESSbytes as follows: B15-B12 are in the first NESSbyte, B11-B6 are in the second NESSbyte and B5-B0 are in the third NESSbyte. Within NESSbytes, bit 6 is always set to 1 and bit 7 is set for odd parity. In the first NESSbyte, bits 5 and 4 are filled by sign extension, i.e. they take the same value as bit 3. As an example, consider the 16-bit source word h0C4E, d3150.

Step 1 - break into 3 formative NESSbytes.

byte 1: XXXX0000
byte 2: XX110001
byte 3: XX001110

Step 2 - sign extend in byte 1, bit 6=1, bit 7=odd parity.

NESSbyte 1:01000000
NESSbyte 2:11110001
NESSbyte 3:11001110

After encoding, the 12-minute block is sent to the data collection platform (DCP) to be transmitted.

Consider the following data set:

Date: March 23 1993 (day 082)
Time of first sample 12:00
Observatory identification: 04342275 (co-latitude 43.4°, longitude 227.5°)
Sensor orientation is XYZF
INTERMAGNET approved filtering
No alert capability
No RMs
Flag #1: 00000000
Flag #2: 00000000
### APPENDIX E-2 (Cont'd)

Minute values of C1, C2, C3, C4

<table>
<thead>
<tr>
<th>Date</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
</tr>
</thead>
<tbody>
<tr>
<td>209062</td>
<td>-56</td>
<td>423216</td>
<td>472036</td>
<td></td>
</tr>
<tr>
<td>209062</td>
<td>-52</td>
<td>423218</td>
<td>472038</td>
<td></td>
</tr>
<tr>
<td>209058</td>
<td>-46</td>
<td>423220</td>
<td>472038</td>
<td></td>
</tr>
<tr>
<td>209053</td>
<td>-49</td>
<td>423219</td>
<td>472035</td>
<td></td>
</tr>
<tr>
<td>209052</td>
<td>-51</td>
<td>423214</td>
<td>472030</td>
<td></td>
</tr>
<tr>
<td>209054</td>
<td>-55</td>
<td>423214</td>
<td>472031</td>
<td></td>
</tr>
<tr>
<td>209061</td>
<td>-56</td>
<td>423215</td>
<td>472035</td>
<td></td>
</tr>
<tr>
<td>209066</td>
<td>-55</td>
<td>423217</td>
<td>472039</td>
<td></td>
</tr>
<tr>
<td>209062</td>
<td>-52</td>
<td>423214</td>
<td>472034</td>
<td></td>
</tr>
<tr>
<td>209055</td>
<td>-54</td>
<td>423212</td>
<td>472030</td>
<td></td>
</tr>
<tr>
<td>209055</td>
<td>-52</td>
<td>423213</td>
<td>472030</td>
<td></td>
</tr>
<tr>
<td>209056</td>
<td>-50</td>
<td>423213</td>
<td>472031</td>
<td></td>
</tr>
</tbody>
</table>

Hex dump of IMFV2.83 binary of this 12-minute block: (126 characters)

```
52  00  2D  99  7F  B3  B9  00  00  B2  8E  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00
00  A6  10  C8  1F  30  15  E4  13  A6  10  CC  1F  2E  15  E2  13  9F  10  CA  1F  2C  15  DE  13  9F  10  CC  1F  2D  15
DE  13  A0  10  CE  1F  2D  15  DF  13
```

After conversion to NESS-BINARY for GOES satellite: (189 characters)

```
45  C8  40  C2  76  D9  C7  FE  73  FB  64  40  40  C2  F2  43  46  CE  40  40  40  40  40  40  40  40  40  40  40
40  40  40  40  40  40  40  40  40  40  40  40  40  40  40  40  7A  58  D0  7C  E0  DF  73  D3  79  F4  D0  7C  7C  DC
43  4C  D5  FE  4C  D3  79  D0  7C  F4  DF  C2  F8  D5  FD  F8  D3  79  F8  D0  7C  64  DF  C2  F8  D5  FD  7C
D3  7A  54  D0  7C  E0  DF  C2  7C  D5  FE  4C  D3  79  68  D0  7C  64  DF  43  C4  D5  FE  DC  D3  7A  58  D0  7C
70  DF  C2  F8  D5  FE  C8  D3  79  7C  D0  7C  68  DF  C2  70  D5  FD  F8  D3  79  7C  D0  7C  70  DF  C2  F4  D5
FD  F8  D3  7A  40  D0  7C  F8  DF  C2  F4  D5  FD  7C  D3
```

### CODING EXAMPLE FOR METEOSAT SATELLITE

As the duration between two time slots on the METEOSAT satellite is one hour, five 12-minute blocks are chained and sent to the DCP for transmission. As a METEOSAT message is 640 bytes long, 10 bytes (hex00) are added to the end of the 630 bytes of the 5 X 12-minute blocks (5 X 126 bytes). Binary from IMFV2.83 format is sent to the DCP without any modification.

Consider the following data set:

Date: March 23 1993 (day 082)  
Time of first sample 12:00  
Observatory identification: 04342275 (co-latitude 43.4°, longitude 227.5°)  
Sensor orientation is XYZF  
INTERMAGNET approved filtering  
No alert capability  
No RMs  
Flag #1: 00000000  
Flag #2: 00000000
### APPENDIX E-2 (Cont'd)

Minute values of C1, C2, C3, C4

<table>
<thead>
<tr>
<th>Block # 1: minute 0-11</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>209062</td>
<td>-56</td>
<td>423216</td>
<td>472036</td>
<td></td>
</tr>
<tr>
<td>209062</td>
<td>-52</td>
<td>423218</td>
<td>472038</td>
<td></td>
</tr>
<tr>
<td>209058</td>
<td>-46</td>
<td>423220</td>
<td>472038</td>
<td></td>
</tr>
<tr>
<td>209053</td>
<td>-49</td>
<td>423219</td>
<td>472035</td>
<td></td>
</tr>
<tr>
<td>209052</td>
<td>-51</td>
<td>423214</td>
<td>472030</td>
<td></td>
</tr>
<tr>
<td>209054</td>
<td>-55</td>
<td>423214</td>
<td>472031</td>
<td></td>
</tr>
<tr>
<td>209061</td>
<td>-56</td>
<td>423215</td>
<td>472035</td>
<td></td>
</tr>
<tr>
<td>209066</td>
<td>-55</td>
<td>423217</td>
<td>472039</td>
<td></td>
</tr>
<tr>
<td>209062</td>
<td>-52</td>
<td>423214</td>
<td>472034</td>
<td></td>
</tr>
<tr>
<td>209055</td>
<td>-54</td>
<td>423212</td>
<td>472030</td>
<td></td>
</tr>
<tr>
<td>209055</td>
<td>-52</td>
<td>423213</td>
<td>472030</td>
<td></td>
</tr>
<tr>
<td>209056</td>
<td>-50</td>
<td>423213</td>
<td>472031</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Block # 2: minute 12-23</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>209059</td>
<td>-45</td>
<td>423215</td>
<td>472034</td>
<td></td>
</tr>
<tr>
<td>209057</td>
<td>-45</td>
<td>423214</td>
<td>472032</td>
<td></td>
</tr>
<tr>
<td>209059</td>
<td>-40</td>
<td>423216</td>
<td>472035</td>
<td></td>
</tr>
<tr>
<td>209057</td>
<td>-42</td>
<td>423214</td>
<td>472032</td>
<td></td>
</tr>
<tr>
<td>209054</td>
<td>-40</td>
<td>423213</td>
<td>472030</td>
<td></td>
</tr>
<tr>
<td>209053</td>
<td>-42</td>
<td>423214</td>
<td>472030</td>
<td></td>
</tr>
<tr>
<td>209048</td>
<td>-45</td>
<td>423214</td>
<td>472028</td>
<td></td>
</tr>
<tr>
<td>209046</td>
<td>-47</td>
<td>423217</td>
<td>472030</td>
<td></td>
</tr>
<tr>
<td>209045</td>
<td>-45</td>
<td>423217</td>
<td>472030</td>
<td></td>
</tr>
<tr>
<td>209044</td>
<td>-46</td>
<td>423217</td>
<td>472029</td>
<td></td>
</tr>
<tr>
<td>209043</td>
<td>-44</td>
<td>423214</td>
<td>472026</td>
<td></td>
</tr>
<tr>
<td>209045</td>
<td>-43</td>
<td>423215</td>
<td>472028</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Block # 3: minute 24-35</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>209050</td>
<td>-44</td>
<td>423215</td>
<td>472030</td>
<td></td>
</tr>
<tr>
<td>209056</td>
<td>-45</td>
<td>423217</td>
<td>472035</td>
<td></td>
</tr>
<tr>
<td>209064</td>
<td>-45</td>
<td>423218</td>
<td>472039</td>
<td></td>
</tr>
<tr>
<td>209072</td>
<td>-43</td>
<td>423217</td>
<td>472042</td>
<td></td>
</tr>
<tr>
<td>209073</td>
<td>-41</td>
<td>423216</td>
<td>472041</td>
<td></td>
</tr>
<tr>
<td>209069</td>
<td>-39</td>
<td>423216</td>
<td>472039</td>
<td></td>
</tr>
<tr>
<td>209063</td>
<td>-37</td>
<td>423215</td>
<td>472036</td>
<td></td>
</tr>
<tr>
<td>209059</td>
<td>-36</td>
<td>423216</td>
<td>472035</td>
<td></td>
</tr>
<tr>
<td>209054</td>
<td>-37</td>
<td>423216</td>
<td>472033</td>
<td></td>
</tr>
<tr>
<td>209051</td>
<td>-42</td>
<td>423215</td>
<td>472030</td>
<td></td>
</tr>
<tr>
<td>209046</td>
<td>-47</td>
<td>423215</td>
<td>472028</td>
<td></td>
</tr>
<tr>
<td>209045</td>
<td>-50</td>
<td>423216</td>
<td>472029</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Block # 4: minute 36-47</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>209061</td>
<td>-56</td>
<td>423216</td>
<td>472036</td>
<td></td>
</tr>
<tr>
<td>209062</td>
<td>-52</td>
<td>423218</td>
<td>472038</td>
<td></td>
</tr>
<tr>
<td>209068</td>
<td>-51</td>
<td>423214</td>
<td>472030</td>
<td></td>
</tr>
<tr>
<td>209066</td>
<td>-55</td>
<td>423217</td>
<td>472039</td>
<td></td>
</tr>
<tr>
<td>209062</td>
<td>-52</td>
<td>423214</td>
<td>472034</td>
<td></td>
</tr>
<tr>
<td>209055</td>
<td>-54</td>
<td>423212</td>
<td>472030</td>
<td></td>
</tr>
<tr>
<td>209055</td>
<td>-52</td>
<td>423213</td>
<td>472030</td>
<td></td>
</tr>
<tr>
<td>209056</td>
<td>-50</td>
<td>423213</td>
<td>472031</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Block # 5: minute 48-59</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>209059</td>
<td>-45</td>
<td>423215</td>
<td>472034</td>
<td></td>
</tr>
<tr>
<td>209057</td>
<td>-45</td>
<td>423214</td>
<td>472032</td>
<td></td>
</tr>
<tr>
<td>209059</td>
<td>-40</td>
<td>423216</td>
<td>472035</td>
<td></td>
</tr>
<tr>
<td>209057</td>
<td>-42</td>
<td>423214</td>
<td>472032</td>
<td></td>
</tr>
<tr>
<td>209054</td>
<td>-40</td>
<td>423213</td>
<td>472030</td>
<td></td>
</tr>
<tr>
<td>209053</td>
<td>-42</td>
<td>423214</td>
<td>472030</td>
<td></td>
</tr>
<tr>
<td>209048</td>
<td>-45</td>
<td>423214</td>
<td>472028</td>
<td></td>
</tr>
<tr>
<td>209046</td>
<td>-47</td>
<td>423217</td>
<td>472030</td>
<td></td>
</tr>
<tr>
<td>209045</td>
<td>-45</td>
<td>423217</td>
<td>472030</td>
<td></td>
</tr>
<tr>
<td>209044</td>
<td>-46</td>
<td>423217</td>
<td>472029</td>
<td></td>
</tr>
<tr>
<td>209043</td>
<td>-44</td>
<td>423214</td>
<td>472026</td>
<td></td>
</tr>
<tr>
<td>209045</td>
<td>-43</td>
<td>423215</td>
<td>472028</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Block # 6: minute 50-61</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>209067</td>
<td>-39</td>
<td>423217</td>
<td>472039</td>
<td></td>
</tr>
<tr>
<td>209067</td>
<td>-39</td>
<td>423217</td>
<td>472039</td>
<td></td>
</tr>
<tr>
<td>209064</td>
<td>-41</td>
<td>423216</td>
<td>472037</td>
<td></td>
</tr>
<tr>
<td>209059</td>
<td>-42</td>
<td>423215</td>
<td>472034</td>
<td></td>
</tr>
<tr>
<td>209058</td>
<td>-41</td>
<td>423215</td>
<td>472034</td>
<td></td>
</tr>
<tr>
<td>209061</td>
<td>-40</td>
<td>423214</td>
<td>472034</td>
<td></td>
</tr>
<tr>
<td>209063</td>
<td>-37</td>
<td>423215</td>
<td>472036</td>
<td></td>
</tr>
<tr>
<td>209060</td>
<td>-37</td>
<td>423215</td>
<td>472034</td>
<td></td>
</tr>
<tr>
<td>209060</td>
<td>-38</td>
<td>423213</td>
<td>472033</td>
<td></td>
</tr>
<tr>
<td>209063</td>
<td>-39</td>
<td>423213</td>
<td>472034</td>
<td></td>
</tr>
<tr>
<td>209063</td>
<td>-40</td>
<td>423212</td>
<td>472033</td>
<td></td>
</tr>
<tr>
<td>209068</td>
<td>-37</td>
<td>423215</td>
<td>472038</td>
<td></td>
</tr>
<tr>
<td>209071</td>
<td>-33</td>
<td>423217</td>
<td>472041</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX E-2 (Cont'd)

Hex dump of IMFV2.83 binary of these five 12-minute blocks:
(5 * 126 + 10 trailing zeros = 640 characters)

```
52 00 2D 99 7F B3 B9 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
C8 1F 30 15 E4 13 A6 10 CC 1F 32 15 E6 13 A2 10
D2 1F 34 15 E6 13 9D 10 CF 1F 33 15 E3 13 9C 10
CD 1F 2E 15 DE 13 9E 10 C9 1F 2E 15 DF 13 A5 10
C8 1F 2F 15 E3 13 AA 10 C9 1F 31 15 E7 13 A6 10
CC 1F 2E 15 E2 13 9F 10 CA 1F 2C 15 DE 13 9F 10
CC 1F 2D 15 DE 13 A0 10 CE 1F 2D 15 DF 13 52 C0
2D 99 7F B3 B9 00 00 B2 31 8E 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
C9 1F 2E 15 E5 13 A1 10 D3 1F 2E 15 E5 13 A3 10 D8 1F
30 15 E3 13 A1 10 D6 1F 2E 15 E0 13 A3 10 D8 1F
2D 15 DE 13 9D 10 D6 1F 2E 15 DE 13 9B 10 D3 1F
2E 15 DC 13 96 10 D1 1F 31 15 DE 13 95 10 D3 1F
31 15 DE 13 94 10 D2 1F 31 15 DD 13 93 10 D4 1F
2E 15 DA 13 95 10 D5 1F 2F 15 DC 13 52 80 2E 99
7F B3 B9 00 00 B2 31 8E 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
DE 13 A0 10 D3 1F 31 15 E3 13 A8 10 D3 1F 32 15
E7 13 B0 10 D5 1F 31 15 EA 13 B1 10 D7 1F 30 15
E9 13 A0 10 D9 1F 30 15 E7 13 A7 10 DB 1F 2F 15
E4 13 A3 10 DC 1F 30 15 E3 13 9E 10 DB 1F 30 15
E1 13 9B 10 D6 1F 2F 15 DE 13 96 10 D1 1F 2F 15
DC 13 95 10 CE 1F 30 15 DD 13 52 40 2F 99 7F B3
B9 00 00 B2 31 8E 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
09 10 C6 1F 2F 15 DB 13 94 10 C4 1F 2F 15 DB 13
99 10 C7 1F 31 15 DF 13 A0 10 CA 1F 31 15 E3 13
A7 10 D0 1F 31 15 E6 13 AC 10 D3 1F 31 15 E8 13
AE 10 D6 1F 30 15 EB 13 B0 10 D8 1F 31 15 EA 13
AE 10 DA 1F 30 15 EB 13 A9 10 D8 1F 2F 15 E5 13
A7 10 D7 1F 2F 15 E4 13 52 00 30 99 7F B3 B9 00
00 B2 31 8E 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
D7 1F 30 15 E5 13 A3 10 D6 1F 2F 15 E2 13 A2 10
D7 1F 2F 15 E2 13 52 10 D8 1F 2E 15 E2 13 57 10
DB 1F 2F 15 54 13 94 10 DB 1F 2F 15 E2 13 57 10
DA 1F 2D 15 E1 13 A7 10 D9 1F 2D 15 E2 13 57 10
DB 1F 2C 15 E1 13 57 10 DB 1F 2F 15 E6 13 57 10
DF 1F 31 15 E9 13 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
```
## APPENDIX E-2 (Cont'd)

### CODING EXAMPLE FOR GMS SATELLITE

The GMS satellite system requires that DCP data transmission use a long preamble, recommends that the length of time for data block be at least 63 seconds, and that transmitted data conform to a specified character set. A base-44 coding algorithm was developed for converting binary data to the GMS character set. The coded data format follows:

**HEADER 21 BYTES CODED**

<table>
<thead>
<tr>
<th>length</th>
<th>position</th>
<th>frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Day of the year</td>
<td>12 bit</td>
<td>3/4 word</td>
</tr>
<tr>
<td>minute of the day</td>
<td>12 bit</td>
<td>3/4 word</td>
</tr>
<tr>
<td>offset C1</td>
<td>12 bit</td>
<td>3/4 word</td>
</tr>
<tr>
<td>offset C2</td>
<td>1/2 word</td>
<td>1.5 word</td>
</tr>
<tr>
<td>offset C3</td>
<td>1/2 word</td>
<td>2.0 word</td>
</tr>
<tr>
<td>offset C4</td>
<td>1/2 word</td>
<td>2.5 word</td>
</tr>
<tr>
<td>Flag #1 &amp; #2</td>
<td>1 word</td>
<td>3.0 word</td>
</tr>
<tr>
<td>station ID, colatitude</td>
<td>12 bit</td>
<td>3/4 word</td>
</tr>
<tr>
<td>longitude</td>
<td>12 bit</td>
<td>3/4 word</td>
</tr>
<tr>
<td>(CR-CR-LF)</td>
<td>21 byte</td>
<td>5.25 word-6.0</td>
</tr>
</tbody>
</table>

**FREE SPACE 27 BYTES CODED**

**D1 Indices and Baseline control**

<table>
<thead>
<tr>
<th>length</th>
<th>position</th>
<th>frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>1/2 word</td>
<td>6.0 word-6.5</td>
</tr>
</tbody>
</table>

**D18 " " " "**

<table>
<thead>
<tr>
<th>length</th>
<th>position</th>
<th>frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>D18</td>
<td>1/2 word</td>
<td>15.0 word-15.0</td>
</tr>
</tbody>
</table>

**MINUTE VALUES 157 BYTES CODED**

- C1 for t+0 minute
- C2 for t+0 minute
- C3 for t+0 minute
- C4 for t+0 minute
- C4 for t+4 minute
- C1 for t+5 minute
- C4 for t+9 minute
- C1 for t+10 minute
- C1 for t+11 minute
- C2 for t+11 minute
- C3 for t+11 minute
- C4 for t+11 minute
- CRC
APPENDIX E-2 (Cont’d)

Time framing for GMS

A multiple data transmission (12-minute data block repeated 3 times) may be used to satisfy the GMS minimum block transmission time of approximately 63 seconds. The time framing for GMS would be:

- no-signal carrier 5.0 second : 5.0 sec
- bit synchronization 2.5 : 7.5
- word synchronization 0.15 : 7.65
- address 0.31 : 7.96

first (64*3+16-1)*8/100 16.56 : 24.52 (177 bytes)
second (64*3+16-1)*8/100 16.56 : 41.08 (177 bytes)
last (64*3+16)*8/100 16.64 : 57.72 (178 bytes)

EOT-EOT-EOT 0.24 : 57.96

The following table shows time slots assigned to DCPs. Each table line represents 60 seconds, the station ID is placed at the beginning of a data transmission block, ’...’ is for the no-signal (carrier only) period, ‘==’ is for synchronization sequence, and ‘===’ is for the data block.

Assigned time slots for the GMS coding would allow 58 seconds per transmission and 7 seconds guard time. This would allow 11 observatories to transmit every 12 minutes.

Base-44 Coding for GMS

The characters used on the GMS system are: LF CR SP ' ( ) + , . / 0 1 2 3 4 5 6 7 8 9 := ? A B C D E F G H I J K L M N O P Q R S T U V W X Y Z (TOTAL 50). The base-44 character set is shown in Table 1.

Each IMFV2.83 data block is encoded by dividing the data block into 16-bit integers. Signed integers are represented by 2’s complement. Each integer value is converted to 3 base-44 numbers, <n1,-n2,n3>, the most significant being n1 and the least significant n3. Each base-44 number may be represented by a base-44 character from Table 1. Example conversions are shown below:

<table>
<thead>
<tr>
<th>DECIMAL</th>
<th>BASE-44</th>
<th>BASE-44</th>
<th>CHAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>&lt;0,0,0&gt;</td>
<td>000</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>&lt;0,0,1&gt;</td>
<td>001</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>&lt;0,0,43&gt;</td>
<td>00?</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>&lt;0,1,0&gt;</td>
<td>010</td>
<td></td>
</tr>
<tr>
<td>32767</td>
<td>&lt;16,40,31&gt;</td>
<td>G-V</td>
<td></td>
</tr>
<tr>
<td>-1</td>
<td>&lt;43,43,43&gt;</td>
<td>??</td>
<td></td>
</tr>
<tr>
<td>-44</td>
<td>&lt;43,43,0&gt;</td>
<td>770</td>
<td></td>
</tr>
<tr>
<td>-1935</td>
<td>&lt;43,0,1&gt;</td>
<td>701</td>
<td></td>
</tr>
<tr>
<td>-32768</td>
<td>&lt;27,3,12&gt;</td>
<td>R1C</td>
<td></td>
</tr>
</tbody>
</table>

Table 1
APPENDIX E-3

IMFV1.23 INTERMAGNET GIN DISSEMINATION FORMAT FOR MINUTE VALUES

Magnetic data, with tenth-nanotesla resolution, are organized on a day file basis. One file contains 24 one-hour blocks, each containing 60 minutes worth of values. Blocks of 60 minutes of data are transmitted. Blocks are padded with 9's if incomplete. Information is coded in ASCII.

File name: To remain compatible with all operating systems, the file name is limited to 8 characters and will contain the date and the three-letter code as an extension. eg: MAR1591.BO for Boulder, March 15, 1991; and JUN2391.OTT for June 23, 1991 at Ottawa.

Description of the header block (64 characters including CrLf)

```
IDC_DDDDDDD_DOY_HH_COMP_T_GIN_COLALONG_DECBAS_RRRRRRRRRRRRRRRRCrLf

IDC : Indicates the IAGA three letter observatory identification (ID) code eg: BOU for Boulder, OTT for Ottawa, LER for Lerwick, etc.

DDDDDDDD : Indicates the date, eg: FEB1591 for February 15, 1991.

DOY : Indicates day of the year (1-366)

HH : Indicates the Hour (0-23). The first line following the header will contain the values corresponding to minute 0 and 1 of this hour. The first value of the day file is hour 0 minute 0.

COMP : Order in which the components are listed, can be HDZF, HDZG, XYZF, XYZG. G represents the difference between a measured ‘Scalar’ F and a computed ‘vector’ F: G = F(vector) - F(scalar). All components excluding D must be in tenths of nT. D must be in hundredths of minutes, east. The F or G component should be included only if it is measured from a scalar instrument independent of the other 3 components otherwise it must be filled with 999999.

T : One-letter code for data type. R=Reported, A=Adjusted, Q=Quasi-definitive, D=Definitive data. Reported data are defined as: the raw data obtained from the IMO, either by satellite, computer link, or other means. It will be formatted in either version IMFV2.8N (binary) or IMFV1.2N (ASCII,) without any RM (Reference Measurements), or other modifications applied to it. Adjusted data are defined as: the Reported data with RM, spike removal, timeshifts, and/or other modifications applied to it. It is emphasized that only one (1) adjusted version of the data would be allowed, to be completed within 7 days of receipt of the Reported data to prevent the proliferation of multiple versions of the Adjusted data. Quasi-definitive data are defined as data that have been corrected using provisional baselines. Produced soon after their acquisition, their accuracy is intended to be very close to that of an observatory’s definitive data product. 98% of the differences between quasi-definitive and definitive data (X, Y, Z) monthly mean values should be less than 5nT. Definitive data are defined as the final adopted data values. Definitive data will only be distributed by the institution responsible for the observatory.

GIN : Three-letter code for GIN responsible for processing the station (IMO) data eg: EDI(Edinburgh), GOL(Golden), OTT(Ottawa), PAR(Paris).

COLALONG : Colatitude and east longitude of the observatory in tenths of degrees.

DECBAS : Baseline declination value in tenths of minutes East (0-216,000). Declination baseline values to be provided annually. If components are X,Y,Z then DECBAS=000000. The DECBAS value is used to allow declination data to exceed 166.66 degrees (which is the limit of the declination elements in each data record without any offset). If the declination is > 166 degrees at an observatory then a DECBAS value should be selected such that the minute samples lie between 0 and 166 degrees. The declination baseline DECBAS should be subtracted from the minute data samples before coding them.

RRR..RRR : Reserved 16 bytes of R-characters for future use.

_ : Indicates a space character.

CrLf : Indicates a Carriage return, Line feed.

Missing values for a vector component must be coded as a space (for the sign bit) followed by six 9 digits: _999999
Missing values for the scalar component must be coded as six 9 digits: 999999
```
APPENDIX E-3 (Cont'd)

IMFV1.23 INTERMAGNET GIN DISSEMINATION FORMAT FOR MINUTE VALUES

Description of data space (64 characters per line including CrLf)

Component values are coded as signed integers, right-justified with a field width of 7. Total field (F) values are coded as unsigned integers, right-justified with a field width of 6. The field widths must be maintained, either through zero-filling or space-filling. The ‘+’ sign for positive values is optional.

Two (2) minutes of data are concatenated on the same line

AAAAAAA_BBBBBBB_CCCCCCC_FFFFFF__AAAAAAA_BBBBBBB_CCCCCCC_FFFFFFCrLf
(values for minute 0) (values for minute 1)
.
.
.

AAAAAAA_BBBBBBB_CCCCCCC_FFFFFF__AAAAAAA_BBBBBBB_CCCCCCC_FFFFFFCrLf
(values for minute 58) (values for minute 59)

AAAAAAA : Indicates Component 1 data field (H,X, etc.).
BBBBBBB : Indicates Component 2 data field (D,Y, etc.).
CCCCCCC : Indicates Component 3 data field (Z,I, etc.).
FFFFF : Indicates Total Field data field.
_ : Indicates space character.
CrLf : Indicates Carriage Return and Line Feed.

Sample of missing values

_999999__999999__999999__999999__999999__999999__999999CrLf

This example represents all components as missing for the first two minutes of the hour. ‘_’ indicates a space character.
APPENDIX E-3 (Cont'd)

IMFV1.22 INTERMAGNET GIN DISSEMINATION FORMAT FOR MINUTE VALUES

Magnetic data, with tenth-nanotesla resolution, are organized on a day file basis. One file contains 24 one-hour blocks, each containing 60 minutes worth of values. Blocks of 60 minutes of data are transmitted. Blocks are padded with 9's if incomplete. Information is coded in ASCII.

File name: To remain compatible with all operating systems, the file name is limited to 8 characters and will contain the date and the three-letter code as an extension. eg: MAR1591.BOU for Boulder, March 15, 1991; and JUN2391.OTT for June 23, 1991 at Ottawa.

Description of the header block (64 characters includingCrLf)

IDC_DDDDDDD_DOY_HH_COMP_T_GIN_COLALONG_DECBAS_RRRRRRRRRRRRRRRRCrLf
IDC : Indicates the IAGA three letter observatory identification (ID) code eg: BOU for Boulder, OTT for Ottawa, LER for Lerwick, etc.
DDDDDDDD : Indicates the date, eg: FEB1591 for February 15, 1991.
DOY : Indicates day of the year (1-366)
HH : Indicates the Hour (0-23). The first line following the header will contain the values corresponding to minute 0 and 1 of this hour. The first value of the day file is hour 0 minute 0.
COMP : Order in which the components are listed, can be HDZF, XYZF. All components excluding D must be in tenths of nT. D must be in hundredths of minutes, east. The F component should be included only if it is measured from a scalar instrument independent of the other 3 components otherwise it must be filled with 999999.
T : One-letter code for data type. R=Reported, A=Adjusted, D=Definitive data.
REPORTED data are defined as: the raw data obtained from the IMO, either by satellite, computer link, or other means. It will be formatted in either version IMFV2.8N (binary) or IMFV1.2N (ASCII,) without any RM (Reference Measurements), or other modifications applied to it.
ADJUSTED data are defined as: the Reported data with RM, spike removal, timeshifts, and/or other modifications applied to it. It is emphasized that only one (1) adjusted version of the data would be allowed, to be completed within 7 days of receipt of the Reported data to prevent the proliferation of multiple versions of the Adjusted data.
DEFINITIVE data are defined as the final adopted data values. Definitive data will only be distributed by the institution responsible for the observatory.
GIN : Three-letter code for GIN responsible for processing the station (IMO) data eg: EDI(Edinburgh), GOL(Golden), OTT(Ottawa), PAR(Paris).
COLALONG : Colatitude and east longitude of the observatory in tenths of degrees.
DECBAS : Baseline declination value in tenth of minutes East (0-216,000). Declination baseline values to be provided annually. If components are X,Y,Z then DECBAS=000000.
RRR..RRR : Reserved 16 bytes of R-characters for future use.
_ : Indicates a space character.
CrLf : Indicates a Carriage return, Line feed.
Missing values for a vector component must be coded as a space (for the sign bit) followed by six 9 digits: _999999
Missing values for the scalar component must be coded as six 9 digits: 999999
APPENDIX E-3 (Cont'd)

IMFV1.22 INTERMAGNET GIN DISSEMINATION FORMAT FOR MINUTE VALUES

**Description of data space** (64 characters per line including CrLf)

Component values are coded as signed integers, right-justified with a field width of 7. Total field (F) values are coded as unsigned integers, right-justified with a field width of 6. The field widths must be maintained, either through zero-filling or space-filling. The ‘+’ sign for positive values is optional.

Two (2) minutes of data are concatenated on the same line

```
AAAAAAA_BBBBBBB_CCCCCCC_FFFFFF__AAAAAAA_BBBBBBB_CCCCCCC_FFFFFF_CrLf
(values for minute 0) (values for minute 1)

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

AAAAAAA_BBBBBBB_CCCCCCC_FFFFFF__AAAAAAA_BBBBBBB_CCCCCCC_FFFFFF_CrLf
(values for minute 58) (values for minute 59)
```

AAAAAAA : Indicates Component 1 data field (H,X, etc.).
BBBBBBB : Indicates Component 2 data field (D,Y, etc.).
CCCCCCC : Indicates Component 3 data field (Z,I, etc.).
FFFFF : Indicates Total Field data field.
_ : Indicates space character.
CrLf : Indicates Carriage Return and Line Feed.

**Sample of missing values**

```
_999999__999999__999999_999999__999999__999999_999999CrLf
```

This example represents all components as missing for the first two minutes of the hour.

‘_’ indicates a space character.
APPENDIX E-4

IBFV2.00 INTERMAGNET BASELINE FORMAT (2009 and AFTER)

This file format is to be used to provide baselines for use in examining equipment and environmental quality (mainly thermal stability of the variometers) and for inclusion on the INTERMAGNET yearly DVD. This format makes room for all published components, including a baseline to scalar data. After a one-line header, the first section contains the observed baseline values on the days when they are measured. Consequently the number of entries will depend upon the schedule for absolute measurements at the observatory. The second section contains adopted baseline values, representing each day of the year. The third section for comments is mandatory. This comment section must include a brief description of the baseline adoption method.

COMP_HHHHH_FFFFF_IDC_YEARCrLf
DDD_aaaaaa(aa_bbbbbb.bb_zzzzzz.zz_ssssss.ssCrLf
                      .................................................CrLf
                      .................................................CrLf
                      .................................................CrLf
DDD_aaaaaa(aa_bbbbbb.bb_zzzzzz.zz_ssssss.ssCrLf
*CrLf
001_AAAAAA.AA_BBBBBB.BB_ZZZZZZ.ZZ_SSSSSS.SS_DDDD.DD_mCrLf
002_AAAAAA.AA_BBBBBB.BB_ZZZZZZ.ZZ_SSSSSS.SS_DDDD.DD_mCrLf
003_AAAAAA.AA_BBBBBB.BB_ZZZZZZ.ZZ_SSSSSS.SS_DDDD.DD_mCrLf
                      .................................................CrLf
                      .................................................CrLf
366_AAAAAA.AA_BBBBBB.BB_ZZZZZZ.ZZ_SSSSSS.SS_DDDD.DD_mCrLf
*CrLf
Comments:CrLf
                      .................................................CrLf
                      .................................................CrLf

Component values are coded as signed float numbers, right justified with format (1X,F9.2). DeltaF values (denoted as DDDD.DD) are coded as signed float numbers, right justified with format (1X,F7.2). The field widths must be maintained, either through zero-filling or space-filling in order to have records of fixed length: every line is 43 characters long in section one, and 53 characters long in section two excluding terminatorCrLf orLf. Comment lines should not exceed 53 characters long.

COMP : Order of components XYZF, DIF_, HDZF, UVZF (see Note 1).
HHHHH : Annual mean value of H component in nT.
FFFFF : Annual mean value of F component in nT.
IDC : Official IAGA three-letter station code in capital letters.
YEAR : 4-digit Year: eg, 2009.
DDD : Day of the year.
aaaaaa.aa : Observed baseline of X, D, H or U in nT or minutes (absolute - variometer)
bbbbbb.bb : Observed baseline of Y, I, D or V in nT or minutes (absolute - variometer)
zzzzzz.zz : Observed baseline of Z or F in nT (absolute - variometer)
ssssss.ss : Observed baseline of Scalar F in nT (absolute - scalar, See Note 5)
AAAAAA.AA : Adopted baseline value of X, D, H or U in nT or minutes.
BBBBBB.BB : Adopted baseline value of Y, I, D or V in nT or minutes.
ZZZZZZ.ZZ : Adopted baseline value of Z, or F in nT.
SSSSSS.SS : Adopted baseline value of Scalar F in nT. (absolute - scalar, See Note 5)
DDDD.DD : Representative value of Delta F for this day (see Note 2).
m : Discontinuity marker (valid values c or d - see Note 3).
* : Section separator.
_ : Space character.
CrLf : Carriage return, Line feed.
APPENDIX E-4 (Cont’d)

IBFV2.00 INTERMAGNET BASELINE FORMAT (2009 and AFTER)

File name convention is IAGYEAR.BLV e.g. BFE2008.BLV

where IAG = 3-letter observatory IAGA code
YEAR = 4-digit year.

Notes: 1. The codes XYZF, DIF_, HDZF, UVZF are the only supported codes of the components which must be listed in specified order within sections one and two.

2. Delta F is defined as:
   \[ \Delta F = F(v) - F(s) \]
   Where F(v) represents the total field value calculated from the main observatory instrument (‘vector F’) and F(s) represents the total field from an independent instrument (‘scalar F’). Both F(v) and F(s) must be corrected to the location in the observatory where geomagnetic absolute observations are made.

3. Discontinuity marker: c indicates that the baselines for all components form a continuous series with the previous day, d indicates a discontinuity in the baseline of one or more components (i.e. step) between the current day and the preceding one. This is to allow the baselines to be plotted at an appropriate scale. A discontinuity is defined as a known operational change such as an instrument re-alignment.

4. Missing values must be replaced by 99999.00 for D, H, X, Y, Z, F and by 999.00 for Delta F. Components that are not observed, which may include Scalar F (SSSSSS.SS) and Delta F (DDDD.DD), must be coded 88888.00 and 888.00 respectively.

5. The observed and adopted F baselines represent the DIFFERENCE in the F component between the absolute position and the continuously recording scalar instrument. Pier corrections are not applied to the data before computing the baselines.
APPENDIX E-4 (Cont’d)

IBFV1.20  INTERMAGNET BASELINE FORMAT (2008 and BEFORE)

This format is to be used to provide baselines for use in examining equipment performance and for inclusion on the INTERMAGNET DVD. The first section contains the observed baseline values on those days on which they were measured. Consequently the number of entries will depend upon the schedule for absolute measurements at that observatory. The second section contains adopted baseline values representing each day of the year. A comment section is also provided.

COMP_HHHHH_IDC_YEARCrLf
DDD_AAAAAAA_BBBBBBBB_ZZZZZZZZCrLf.

* 001_AAAAAAA_BBBBBBBB_ZZZZZZZZ_FFFFFCrLf.
    . . . . . . . .CrLf.
    DDD_AAAAAAA_BBBBBBBB_ZZZZZZZZCrLf.
    * 366_AAAAAAA_BBBBBBBB_ZZZZZZZZ_FFFFFCrLf.

Comments:

Component values are coded as signed integers, right-justified with a field width of 7. Total field (Delta F) values are coded as signed integers, right-justified with a field width of 5. The field widths must be maintained, either through zero-filling or space-filling. The ‘+’ sign for positive values is optional.

COMP : Order of components HDZF, XYZF, DIF, UVZF
HHHHHH : Annual mean value of H component in nT.
IDC : IAGA three-letter observatory ID code eg: BOU for Boulder, OTT for Ottawa, LER for Lerwick, etc.
YEAR : 4-digit Year: for example, 1991.
DDD : Day of the year
AAAAAAA : Signed value of H, D, U or X in 0.1 nT
BBBBBBB : Signed value of D, I, V or Y in 0.1 nT or 0.1 min of arc for D
ZZZZZZZ : Signed value of Z or F in 0.1 nT
FFFFF : Signed value of Delta F, the difference between calculated and observed value of F (by a proton magnetometer) in 0.1 nT
* : Section separator.
_ : Space character
CrLf : Carriage return, Line feed

Missing values must be replaced by 999999 for D, H, X, Y, Z and by 9999 for F.

File name convention is IAGYR.BLV

where  IAG = 3-letter observatory IAGA code
      YR = 2-digit year.
APPENDIX E-5

IAGA2002 INTERMAGNET EXCHANGE FORMAT (Spreadsheet compatible)

This ASCII Exchange Format, adopted in August 2001 and revised in December 2001 and in July 2003, is intended as a data exchange format for geomagnetic data (samples and means) from observatories and variometer stations at time intervals from millisecond up to and including monthly means. The format comprises:

- Twelve (12) mandatory file header records.
- Unlimited optional comment records.
- One (1) mandatory data header record.
- A series of data records.
- Every record is 70 characters long plus the machine-dependent carriage return / line feed.

Pad records with spaces if needed. Data records report exactly 4 magnetic field elements (DHIF, DHZF, or XYZF). Use missing data values (8's or 9's) if fewer than 4 elements are available.

THE 12 MANDATORY FILE HEADER RECORDS

Mandatory header and optional comment records begin with a space character in column 1 and end with the vertical bar | (ASCII 124) in column 70. Content labels begin in column 2 and descriptions begin in column 25.

- This Format is designated IAGA-2002.
- Source of Data is the name of the institute responsible for collecting the data.
- Please spell the entire Station Name; do not use abbreviations. Capitalize the first letter.
- The IAGA Code is the official IAGA 3-letter station code. It should be in capital letters and correspond to the IAGA list of magnetic observatories. Variation stations must check observer suggested 3-letter codes against the IAGA list (WDC SEG, Boulder) and confirm through the IAGA Division V WG1 or leave the code blank.
- Location of the station is reported to the one thousandth degree in Geodetic Latitude (positive north) from -90 to 90 degrees and in
- Geodetic Longitude (positive east) from -180 to 180 or 0 to 360 degrees.
- Report Elevation in meters above mean sea level.
- Reported refers to the magnetic field elements contained in the data record, in the order recorded in data record. Valid values are HDIF, DHIF, HDZF, DHZF, and XYZF. Use E/V instead of D/I for declination/inclination given in intensity units (ONLY if data type is variation).
- Sensor Orientation is the physical orientation of the observing instruments, i.e. XYZ, HDZ.
- Digital Sampling is the rate (in seconds) of the data sampling of the magnetic field sensor (instrument) or the digitizing interval for analogue data.
- Data Interval Type is the mean or instantaneous time interval of the data. Common values include 1-minute (00:30-01:29), 1-minute (00:00-00:59), 1-hour (00-59), 1-day (00-23) and 1-month (01-31); the last day could also be 30, 29, or 28. There are many possible intervals, including a fraction of a second (instant value), averages by 1-second (501-1500), 1- second (0-1000), 10 second, or 2.5 minute. Define the type of mean and how values are centered in the comment section.
- Data Type is provisional, definitive, or variation

THE OPTIONAL COMMENT HEADER RECORDS

Use these records to record important information concerning the data that is not contained in the defined fields. Types of information may include the type of means and how the mean values are centered, important gaps in the data record, or explanations of missing values (9 filled element field).

- Every record begins with a space character in column 1 and # (hash or number sign) in column 2.
- The end of each record is indicated with a vertical bar | (ASCII 124) in column 70.
• For transmission of incomplete day files include two additional optional comment headers stating the start time and duration in seconds. These records must have the form:
  #Start Time hh:mm:ss
  #Duration-in-seconds sssss

• If the data file contains absolute values (Data Type provisional or definitive), include the formula for computing the missing (non-reported) magnetic elements. For example, if an observatory reports XYZF, the comments should contain the formula for computing HDI (see sample data header and data record for 1-minute values).

• If the data file contains variometer values without considering base line values (Data Type variation), formula and constants are to be given to convert the recorded magnetic elements into others or to convert angular units into nT or vice versa. The possible conversions are:
  o \( E = D \times Ha \times \text{arc}(1') \)
  o \( V = I \times Fa \times \text{arc}(1') \)
  o \( X = H \times \cos(Da) - E \times \sin(Da) \)
  o \( Y = H \times \sin(Da) - E \times \cos(Da) \)
  o \( Z = F \times \sin(Ia) + V \times \cos(Ia) \)
  o \( F = Z \times \sin(Ia) + H \times \cos(Ia) \)
  o \( H = X \times \cos(Da) + Y \times \sin(Da) = F \times \cos(Ia) - V \times \sin(Ia) \)
  o \( E = Y \times \cos(Da) - X \times \sin(Da) \)
  o \( V = Z \times \cos(Ia) - H \times \sin(Ia) \)

X, Y, Z, H, F, E, V in nT; D, I in minutes of arc

\( \text{arc}(1') = 2.9089E-04 = 0.00029089 \)

Ha, Fa, Da, Ia : approximate values of H, F, D, I (eg the most recent annual mean value or a value from the IGRF)

The formula and constants are to be given in additional optional comment header lines (see sample data header and data record for 1-second values).

THE MANDATORY DATA HEADER RECORD

The mandatory data-header record contains column headers useful for multi-station analysis. Elements, both type and order, are indicated in the file-header field \textit{Reported}.

• The date and time headers are DATE, TIME, and DOY (day of year).
• The magnetic element headers comprise 4 letters: 3 letters for the observatory IAGA code and 1 letter for the magnetic element reported. Valid values are H, D (or E), I (or V), X, Y, Z, F. The column headers are space delimited.
• The end of each record is indicated with a vertical bar | (ASCII 124) in column 70.

THE DATA RECORDS

The data records contain the date, time, and magnetic field elements reported. Report data to the least significant digit. Indicate missing data with 999999 (e.g., 99999.00). If an element is not observed, please record 88888 in that field. The format for field elements is 4(1X, F9.2). Each record is exactly 70 characters long plus the machine dependent carriage return / line feed.

• DATE is the calendar date in ISO YYYY-MM-DD format (4-digit year, month as 01-12, day as 01-31).
• TIME is in ISO hh:mm:ss.sss format (hour as 0-24, minute as 0-59, second as 0-59 Note: if the hour is 24, the minute and second must be 0). Values beyond the time interval of the means being reported must be zero-filled i.e. 14:01:00.000 for 1 minute data for the 14th hour, first minute. Describe the method of average, i.e., centered to the hour for hourly means, in the comments area.
• DOY is the day of the year, from 1 - 365 (or 366 for leap years).
• D and I are reported in angular units of minutes of arc to the precision of the instruments. F, H, X, Y, Z, E, and V are reported in nanotesla and a fraction of nT.
RECOMMENDED FILE NAME PROCEDURE

To improve the ease with which data are exchanged and recognized, IAGA recommends the following guidelines and style for naming files containing magnetic observatory data. The recommendations closely follow the current International Standards Organization (ISO) Level II recommendations, and are fully compliant with both the Joliette extension to Level II and to the proposed modifications for the ISO standard. These recommendations are for data exchange and do not necessarily apply to data archive. Some changes have been made in this section in July 2003 to allow for existence of multiple fragments of data starting at different times (which is a possibility for some data transmission systems) and to ease usage with compression programs.

- File names are composed of two parts, the base name and a three-character extension. A full stop (period) separates the base from the extension. The base name may be up to 27 characters long. The extension is exactly three characters (total file name length not to exceed 31 characters). This format is sometimes referred to as the "27.3" format. BASENAME (1 to 27 characters) "." EXTENSION (3 characters). Ex. my_file_name.dat
- File names are composed of lower case a-z, 0-9, underscore "_", and dash "-" characters. No spaces, unusual characters (i.e. *, /, \, :, ;, ?) or upper case characters allowed.
- File names must begin with the IAGA 3-Letter Code, Date, and Type of data. The Extension defines the Data Interval (monthly, daily, hourly, minute, or second data). The Extension is duplicated in the last three characters of the base name, so that if the Extension is stripped on compression the Data Interval is not lost. The file name only indicates the general data interval, specific information is contained in the file header Data Interval field (i.e. 2.5 and 1-minute averages are both "minute" data, 10 second averages and 1 second instantaneous are both "second" data).
- The first several characters in the base name are strictly defined. Files may be further defined with the remaining characters by using an underscore "_" to separate the standard name. For example, naq20020101d.min and naq20020101d_2-5.min are both acceptable names for 2.5 minute definitive data from Narsarsuaq.

General format: iagyyyyymmdttint.int

Where:
  iag = IAGA 3-letter observatory code
  yyyy = four digit year (i.e. 2002)
  mm = two digit month (i.e. 01 for January, 12 for December)
  dd = two digit day of month (01-31)
  t = type of data (p - provisional, d - definitive, v - variation)
  int = data interval (mon - monthly, day - daily, hor - hourly, min - minute, sec - second).

<table>
<thead>
<tr>
<th>Comment</th>
<th>Data Interval</th>
<th>Files</th>
<th>File Name Pattern</th>
<th>Example Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Monthly</td>
<td>Year</td>
<td>iagyyyyytint.int</td>
<td>naq2002dmon.mon</td>
</tr>
<tr>
<td>2</td>
<td>Daily</td>
<td>Year</td>
<td>iagyyyyytint.int</td>
<td>naq2002dday.day</td>
</tr>
<tr>
<td>3</td>
<td>Hourly</td>
<td>Month</td>
<td>iagyyyyymmtint.int</td>
<td>naq200201phor.hor</td>
</tr>
<tr>
<td>4</td>
<td>Minute</td>
<td>Day</td>
<td>iagyyyyymmddttint.int</td>
<td>naq20020101pmin.min</td>
</tr>
<tr>
<td>5</td>
<td>Second</td>
<td>Day</td>
<td>iagyyyyymmdttint.int</td>
<td>naq20020211vsec.sec</td>
</tr>
</tbody>
</table>

1. File contains 1 year of definitive monthly data for 2002 from Narsarsuaq.
2. File contains 1 year of definitive daily data for 2002 from Narsarsuaq.
4. File contains 1 day of provisional minute data for 1 January 2002 from Narsarsuaq.
5. File contains 1 day of variation second data for 11 February 2002 from Narsarsuaq.

Additional format to handle multiple fragments of data starting at different times: iagyyyyymmdhhMMsstint.int
Where:

- \( iag \) = IAGA 3-letter observatory code
- \( yyyy \) = four digit year (i.e. 2002)
- \( mm \) = two digit month (i.e. 01 for January, 12 for December)
- \( dd \) = two digit day of month (01-31)
- \( hh \) = hour at which data starts (00-23)
- \( MM \) = minute at which data starts (00-59)
- \( ss \) = second at which data starts (00-59)
- \( t \) = type of data (p - provisional, d - definitive, v - variation)
- \( int \) = data interval (mon - monthly, day - daily, hor - hourly, min - minute, sec - second)

<table>
<thead>
<tr>
<th>Comment</th>
<th>Data Interval</th>
<th>Files</th>
<th>File Name Pattern</th>
<th>Example Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Minute</td>
<td>Part-day</td>
<td>iagyyyymmddhhMMtint.int</td>
<td>clf200306121320vmin.min</td>
</tr>
<tr>
<td>2</td>
<td>Second</td>
<td>Part-day</td>
<td>iagyyyymmddhhMMsstint.int</td>
<td>clf20030612132000vsec.sec</td>
</tr>
</tbody>
</table>

1. File contains part-day of 1-minute variation data from CLF for 12 June 2003, starting at 13:20
2. File contains part-day of 1-second variation data from CLF for 12 June 2003, starting at 13:20:00

SAMPLE OF IAGA-2002 FORMAT JULY 2003 REVISION

SAMPLE DATA HEADER AND DATA RECORD FOR 1-MINUTE VALUES

<table>
<thead>
<tr>
<th>Format</th>
<th>IAGA-2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source of Data</td>
<td>Danish Meteorological Institute</td>
</tr>
<tr>
<td>Station Name</td>
<td>Narsarsuaq</td>
</tr>
<tr>
<td>IAGA Code</td>
<td>NAQ</td>
</tr>
<tr>
<td>Geodetic Latitude</td>
<td>61.160</td>
</tr>
<tr>
<td>Geodetic Longitude</td>
<td>314.560</td>
</tr>
<tr>
<td>Elevation</td>
<td>4</td>
</tr>
<tr>
<td>Reported</td>
<td>XYZF</td>
</tr>
<tr>
<td>Sensor Orientation</td>
<td>DIF</td>
</tr>
<tr>
<td>Digital Sampling</td>
<td>0.01 seconds</td>
</tr>
<tr>
<td>Data Interval Type</td>
<td>Filtered 1-minute (00:30 - 01:29)</td>
</tr>
<tr>
<td>Data Type</td>
<td>Definitive</td>
</tr>
</tbody>
</table>

# This area is where the data source or distributor can include
# any additional information needed for proper use of data. For
# example, the observers name and contact, notes on a change of
# instrumentation, reasons for missing data values, definition of
# observed values, geomagnetic location of the observatory, etc.
# This area should also contain the formula for computing the non-
# reported elements and components of the INTERMAGNET binary
# format which do not fit elsewhere. These include:
# D-conversion:
# = H/3438*10000.
# which is word 8 in the INTERMAGNET binary format and is used
# to convert variations of D in minutes of arc <-> nT. Please
# note that all of the header records and comment records begin
# with a space in column 1, end with a | (ASCII 124), and are
# padded with spaces - never with tabs.

\[
DATE \quad TIME \quad DOY \quad NAQX \quad NAQY \quad NAQZ \quad NAQF
\]

| 2001-03-13 00:00:00.000 072 | 10800.11 | -6100.23 | 53381.51 | 54801.12 |
| 2001-03-13 00:01:00.000 072 | 10800.31 | -6100.20 | 53381.51 | 54801.12 |
| 2001-03-13 00:02:00.000 072 | 10801.11 | -6101.23 | 99999.00 | 54801.12 |
| 2001-03-13 00:03:00.000 072 | 10803.12 | -6100.23 | 99999.00 | 54801.12 |
SAMPLE DATA HEADER AND DATA RECORD FOR HOURLY VALUES

The header record for Data Interval Type might read:
Data Interval Type  1-hour (00 - 59). Note filler for non-reported element.

<table>
<thead>
<tr>
<th>DATE</th>
<th>TIME</th>
<th>DOY</th>
<th>NAQX</th>
<th>NAQY</th>
<th>NAQZ</th>
<th>NAQF</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001-03-13 00:00:00.000</td>
<td>072</td>
<td>10800.11</td>
<td>-6100.23</td>
<td>53381.51</td>
<td>88888.00</td>
<td></td>
</tr>
<tr>
<td>2001-03-13 01:00:00.000</td>
<td>072</td>
<td>10801.11</td>
<td>-6100.20</td>
<td>53381.51</td>
<td>88888.00</td>
<td></td>
</tr>
<tr>
<td>2001-03-13 02:00:00.000</td>
<td>072</td>
<td>10803.12</td>
<td>-6100.23</td>
<td>99999.00</td>
<td>88888.00</td>
<td></td>
</tr>
</tbody>
</table>

SAMPLE DATA HEADER AND DATA RECORD FOR MONTHLY VALUES

The header record for Data Interval Type might read:
Data Interval Type  1-month (01 - 31). Note filler for non-reported element.

<table>
<thead>
<tr>
<th>DATE</th>
<th>TIME</th>
<th>DOY</th>
<th>NAQX</th>
<th>NAQY</th>
<th>NAQZ</th>
<th>NAQF</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001-01-15 00:00:00.000</td>
<td>015</td>
<td>10800.11</td>
<td>-6100.23</td>
<td>53381.51</td>
<td>88888.00</td>
<td></td>
</tr>
<tr>
<td>2001-02-14 00:00:00.000</td>
<td>045</td>
<td>10800.31</td>
<td>-6100.20</td>
<td>53381.51</td>
<td>88888.00</td>
<td></td>
</tr>
<tr>
<td>2001-03-15 00:00:00.000</td>
<td>074</td>
<td>10801.11</td>
<td>-6101.23</td>
<td>53381.50</td>
<td>88888.00</td>
<td></td>
</tr>
<tr>
<td>2001-04-15 00:00:00.000</td>
<td>105</td>
<td>10803.12</td>
<td>-6100.23</td>
<td>99999.00</td>
<td>88888.00</td>
<td></td>
</tr>
</tbody>
</table>

SAMPLE DATA HEADER AND DATA RECORD FOR 1-SECOND VALUES

Format IAGA-2002
Source of Data Danish Meteorological Institute
Station Name Narsarsuaq
IAGA CODE NAQ
Geodetic Latitude 61.160
Geodetic Longitude 314.560
Elevation 4
Reported HEZF
Sensor Orientation HEZF
Digital Sampling 1 seconds
Data Interval Type 1-second instantaneous
Data Type Variation

This area should contain additional information needed
in order to transform the reported elements. For the data in this
sample information about the declination at the observatory is
needed in order to transform the variation data from HEZ to the
widely used XYZ orientation. Also information about the value of
horizontal field H can be useful to convert E-variations in nT to
variations in minutes of arcs.

E = D * Ha * 0.00029089
Ha = 17123.45
X = H * cos(Da) - E* sin(Da)
Y = H * sin(Da) + E* cos(Da)
Da = 312.89 minutes of arc

<table>
<thead>
<tr>
<th>DATE</th>
<th>TIME</th>
<th>DOY</th>
<th>NAQH</th>
<th>NAQE</th>
<th>NAQZ</th>
<th>NAQF</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001-03-13 00:00:00.000</td>
<td>072</td>
<td>800.11</td>
<td>-100.23</td>
<td>381.51</td>
<td>54801.12</td>
<td></td>
</tr>
<tr>
<td>2001-03-13 00:00:01.000</td>
<td>072</td>
<td>800.31</td>
<td>-100.20</td>
<td>381.51</td>
<td>54802.32</td>
<td></td>
</tr>
<tr>
<td>2001-03-13 00:00:02.000</td>
<td>072</td>
<td>801.11</td>
<td>-101.23</td>
<td>99999.00</td>
<td>54803.22</td>
<td></td>
</tr>
<tr>
<td>2001-03-13 00:00:03.000</td>
<td>072</td>
<td>803.12</td>
<td>-100.23</td>
<td>99999.00</td>
<td>54803.43</td>
<td></td>
</tr>
</tbody>
</table>
### SAMPLE DATA HEADER AND DATA RECORD FOR 5-MILLISECOND VALUES

The header record for Data Interval Type might read:

Data Interval Type  5-millisecond (instantaneous values).  Note filler for missing element.

<table>
<thead>
<tr>
<th>DATE</th>
<th>TIME</th>
<th>DOY</th>
<th>NAQX</th>
<th>NAQY</th>
<th>NAQZ</th>
<th>NAQF</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001-03-13</td>
<td>00:00:00.000</td>
<td>72</td>
<td>10800.11</td>
<td>-6100.23</td>
<td>53381.51</td>
<td>99999.00</td>
</tr>
<tr>
<td>2001-03-13</td>
<td>00:00:00.005</td>
<td>72</td>
<td>10800.31</td>
<td>-6100.20</td>
<td>53381.51</td>
<td>99999.00</td>
</tr>
<tr>
<td>2001-03-13</td>
<td>00:00:00.010</td>
<td>72</td>
<td>10801.11</td>
<td>-6101.23</td>
<td>53381.50</td>
<td>54801.10</td>
</tr>
<tr>
<td>2001-03-13</td>
<td>00:00:00.015</td>
<td>72</td>
<td>10803.12</td>
<td>-6100.23</td>
<td>99999.00</td>
<td>54801.24</td>
</tr>
</tbody>
</table>
APPENDIX F-1

FILTER COEFFICIENTS TO PRODUCE ONE MINUTE VALUES

<table>
<thead>
<tr>
<th>Time in Second s</th>
<th>Coef. for One Second Data</th>
<th>Coef. for Five Second Data</th>
<th>Coef. For Ten Second Data</th>
<th>Time in Second s</th>
<th>Coef. for One Second Data</th>
<th>Coef. for Five Second Data</th>
<th>Coef. for Ten Second Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>t₀</td>
<td>0.02519580</td>
<td>0.12578865</td>
<td>0.25100743</td>
<td>t₂₆</td>
<td>0.00661811</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t₁</td>
<td>0.02514602</td>
<td></td>
<td></td>
<td>t₂₇</td>
<td>0.00595955</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t₂</td>
<td>0.02499727</td>
<td></td>
<td></td>
<td>t₂₈</td>
<td>0.00534535</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t₃</td>
<td>0.02475132</td>
<td></td>
<td></td>
<td>t₂₈</td>
<td>0.00477552</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t₄</td>
<td>0.02441104</td>
<td></td>
<td></td>
<td>t₃₀</td>
<td>0.00424959</td>
<td>0.02121585</td>
<td>0.04233562</td>
</tr>
<tr>
<td>t₅</td>
<td>0.02398040</td>
<td>0.11972085</td>
<td></td>
<td>t₃₁</td>
<td>0.00376666</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t₆</td>
<td>0.02346437</td>
<td></td>
<td></td>
<td>t₃₂</td>
<td>0.00332543</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t₇</td>
<td>0.02286881</td>
<td></td>
<td></td>
<td>t₃₃</td>
<td>0.00292430</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t₈</td>
<td>0.02220039</td>
<td></td>
<td></td>
<td>t₃₄</td>
<td>0.00256140</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t₉</td>
<td>0.02146643</td>
<td></td>
<td></td>
<td>t₃₅</td>
<td>0.00223468</td>
<td>0.01115655</td>
<td></td>
</tr>
<tr>
<td>t₁₀</td>
<td>0.02067480</td>
<td>0.10321785</td>
<td>0.20596804</td>
<td>t₃₆</td>
<td>0.00194194</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t₁₁</td>
<td>0.01983377</td>
<td></td>
<td></td>
<td>t₃₇</td>
<td>0.00168089</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t₁₂</td>
<td>0.01895183</td>
<td></td>
<td></td>
<td>t₃₈</td>
<td>0.00144918</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t₁₃</td>
<td>0.01803763</td>
<td></td>
<td></td>
<td>t₃₉</td>
<td>0.00124449</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t₁₄</td>
<td>0.01709976</td>
<td></td>
<td></td>
<td>t₄₀</td>
<td>0.00106449</td>
<td>0.00531440</td>
<td>0.01060471</td>
</tr>
<tr>
<td>t₁₅</td>
<td>0.01614667</td>
<td>0.08061140</td>
<td></td>
<td>t₄₁</td>
<td>0.00090693</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t₁₆</td>
<td>0.01518651</td>
<td></td>
<td></td>
<td>t₄₂</td>
<td>0.00076964</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t₁₇</td>
<td>0.01422707</td>
<td></td>
<td></td>
<td>t₄₃</td>
<td>0.00065055</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t₁₈</td>
<td>0.01327563</td>
<td></td>
<td></td>
<td>t₄₄</td>
<td>0.00054772</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t₁₉</td>
<td>0.01233892</td>
<td></td>
<td></td>
<td>t₄₅</td>
<td>0.00045933</td>
<td>0.00229315</td>
<td></td>
</tr>
<tr>
<td>t₂₀</td>
<td>0.01142303</td>
<td>0.05702885</td>
<td>0.11379931</td>
<td>t₄₆</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>t₂₁</td>
<td>0.01053338</td>
<td></td>
<td></td>
<td>t₄₇</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>t₂₂</td>
<td>0.00967467</td>
<td></td>
<td></td>
<td>t₄₈</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>t₂₃</td>
<td>0.00885090</td>
<td></td>
<td></td>
<td>t₄₉</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>t₂₄</td>
<td>0.00806530</td>
<td></td>
<td></td>
<td>t₵₀</td>
<td></td>
<td></td>
<td>0.00178860</td>
</tr>
<tr>
<td>t₂₅</td>
<td>0.00732042</td>
<td>0.03654680</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX G-1

INTERMAGNET MEMBERSHIP APPLICATION (V-2.6 September 2012)

An Institution must apply for membership in INTERMAGNET by mailing this completed application form to:

Christopher W. Turbitt,
INTERMAGNET
c/o British Geological Survey
Murchison House
West Mains Road
Edinburgh EH9 3LA
UK

This application form is also available in PDF, Word and WordPerfect from the INTERMAGNET Web site.

Application for membership implies that the Institution will agree to do the following:

1. Abide by the INTERMAGNET Principles and Conditions (Section 1.4)
2. Comply with INTERMAGNET Formats and Technical Standards.
3. Keep its IMOs within specifications and in operation.
4. If using satellite communication, keep its DCPs operating within allotted transmission time 'windows'. Upon receipt of notification from a Geomagnetic Information Node (GIN) that a DCP is transmitting outside of its allotted time window, the responsible Institute agrees to stop the transmission or correct the timing of transmission within 24 hours.
5. Provide definitive data from its IMOs for the annual CD-ROM.
6. Communicate any instrument or practice change to the IMO sub-committee chairman.

IMOs not complying with these conditions or not submitting data for two years risk removal of IMO status.

INTERMAGNET will:

1. Provide on-line access to data from all IMOs for up to 1 year.
2. Provide definitive data from IMOs on a CD-ROM within approximately 6 months of the end of each year.

More information on the application form can be obtained from the IMO sub-committee chairman:

Christopher W. Turbitt
British Geological Survey
Murchison House
West Mains Road
Edinburgh EH9 3LA
UK
TEL: 44-131-667-1000
FAX: 44-131-667-1877
INTERNET: c.turbitt@bgs.ac.uk

DOCUMENTS AVAILABLE

INTERMAGNET Membership Application.
Suppliers of Observatory and Data Transmission Equipment.
APPENDIX G-1 (Cont'd)

INTERMAGNET MEMBERSHIP APPLICATION FORM (V-2.6 September 2012)

Date submitted: _______________________

OBSERVATORY

Name: ________________________________ IAGA code: __________
Latitude: ____________________________ Longitude: ____________________________
Elevation: ____________________________
Street Address: _______________________
City: ____________________________ Prov/State: ________________
Country: ____________________________ Code/Zip: ________________
Phone: ____________________________ (with country code)
Fax: ________________________________
E-mail: ______________________________

OBSERVATORY CONTACT

Name: ________________________________
Street Address: _______________________
City: ____________________________ Prov/State: ________________
Country: ____________________________ Code/Zip: ________________
Phone: ____________________________ (with country code)
Fax: ________________________________
E-mail: ______________________________

INSTITUTION

Name: ________________________________
Contact name: _________________________
Street Address: _________________________
City: ____________________________ Prov/State: ________________
Country: ____________________________ Code/Zip: ________________
Phone: ____________________________ (with country code)
Fax: ________________________________
E-mail: ______________________________
APPENDIX G-1 (Cont'd)

INTERMAGNET INSTRUMENT SPECIFICATION FORM (V-2.6 September 2012)

Values shown in square brackets [ ] are target values.

A. CONTINUOUSLY RECORDING VECTOR MAGNETOMETER

Instrument Type: ________________________________
Manufacturer: ________________________________

Components Measured XYZ ( ) HDZ ( ) DIF ( ) Other: _______
Sensor tilt correcting suspension: Yes ( ) No ( )
Resolution of digital data [0.1nT]: _nT
Automatic dynamic range of digital data: _nT
Sampling rate of digital data: __________ Sec.
Digital filtering conforms to INTERMAGNET specification: Yes ( ) No ( )
If not in conformance, please give details of the filtering algorithm used: ________________________________

Sensor thermal coefficient [0.25nT/°C]: _nT/°C
Electronics thermal coefficient [0.25nT/°C]: _nT/°C
Temperature variation range expected for sensor: __________ °C
Temperature variation range expected for electronics: __________ °C

B. CONTINUOUSLY RECORDING SCALAR MAGNETOMETER

Instrument Type: ________________________________
Manufacturer: ________________________________

Resolution of digital data: __________ nT
Automatic dynamic range of digital data: __________ nT
Sampling rate of digital data: __________ Sec.

C. DATA ACQUISITION SYSTEM

Time synchronization: Yes ( ) No ( )
Maximum time error if not synchronized: __________ Sec./Month
Recorded data files: [check all that apply] Recorded Filtered

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1min</td>
<td>(   )</td>
<td>( )( )</td>
</tr>
<tr>
<td>5sec</td>
<td>(   )</td>
<td>( )( )</td>
</tr>
<tr>
<td>1sec</td>
<td>(   )</td>
<td>( )( )</td>
</tr>
<tr>
<td>Other</td>
<td>(   )</td>
<td>( )( )</td>
</tr>
</tbody>
</table>

Data storage capacity: ____________ Weeks

Uninterruptible power supply: Yes ( ) No ( )
If yes: ____________ Hours

D. DATA TRANSMISSION

An IMO must communicate its data to a GIN within 72 hours either by Satellite or E-mail. Three months of data transmission are required before the INTERMAGNET membership application is considered.

1. Satellite Transmission

Satellite: GOES W ( ) GOES E ( ) METEOSAT ( ) GMS ( ) Other: _________
Transmitter Type: ____________________
DCP address: ____________________
DCP channel: ____________________
Response time: ____________ Hours (This is the time it would take to shut off your transmitter if INTERMAGNET determines that your DCP timing has drifted into another satellite transmission slot)

2. E-mail communication

Sent to GIN: Edinburgh ( ) Golden ( ) Kyoto ( ) Ottawa ( ) Paris ( )
Frequency of transmission: Daily ( ) 2 days ( ) 3 days ( ) Other: _________
Observatory or data relay E-mail: ____________________

E. OBSERVATORY BASELINE INFORMATION

Along with this application form (using the Data Quality Control section of the Technical Reference Manual as a reference), please submit a sample of the observatory baselines for a minimum 1 year interval. Preferably, these data should be presented in graphical form using the Excel spreadsheet available on the INTERMAGNET Web site which produces baseline graphs of observed and adopted baseline values in a standard format. Please give details on the baseline adoption procedure and explain offsets if there are any. Also, please submit the one-minute raw data using standard INTERMAGNET formats for the same period including the total field value recorded by a total field magnetometer if available.

Expected baseline variation [5nT/year]: _______________ nT/year
APPENDIX G-1 (Cont'd)

F. ABSOLUTE INSTRUMENTS

Measurement frequency: ______________________

1. Declination (D)

Instrument Type: _______________________________
Manufacturer: _________________________________
Measurement accuracy: _________________________

2. Inclination (I)

Instrument Type: _______________________________
Manufacturer: _________________________________
Measurement accuracy: _________________________

3. Total field (F)

Instrument Type: _______________________________
Manufacturer: _________________________________
Measurement accuracy: _________________________

4. Horizontal component (H)

Instrument Type: _______________________________
Manufacturer: _________________________________
Measurement accuracy: _________________________

5. Vertical component (Z)

Instrument Type: _______________________________
Manufacturer: _________________________________
Measurement accuracy: _________________________
Acknowledgments

We gratefully acknowledge the many and significant contributions to the Executive Council and Operations Committee provided by past members.

<table>
<thead>
<tr>
<th>EXCON</th>
<th>OPSCOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>William F. Stuart</td>
<td>Lanny Wilson</td>
</tr>
<tr>
<td>Arthur W. Green Jr.</td>
<td>Doug F. Trigg</td>
</tr>
<tr>
<td>Richard L. Coles</td>
<td>Francois-Xavier Lalanne</td>
</tr>
<tr>
<td>Jean-Louis LeMouël</td>
<td>Gerrit Jansen van Beek</td>
</tr>
<tr>
<td>Larry Newitt</td>
<td>Michèle Bitterly</td>
</tr>
<tr>
<td></td>
<td>Jacques Bitterly</td>
</tr>
<tr>
<td></td>
<td>John Riddick</td>
</tr>
<tr>
<td></td>
<td>Edward A. Sauter</td>
</tr>
<tr>
<td></td>
<td>Jennifer Parmelee</td>
</tr>
<tr>
<td></td>
<td>Toyohisa Kamei</td>
</tr>
<tr>
<td></td>
<td>Ole Rasmussen</td>
</tr>
<tr>
<td></td>
<td>Lee Pankratz</td>
</tr>
<tr>
<td></td>
<td>Donald C. Herzog</td>
</tr>
<tr>
<td></td>
<td>Laszlo Hegymegi</td>
</tr>
<tr>
<td></td>
<td>Danielle Fouassier</td>
</tr>
<tr>
<td></td>
<td>Jean-Jacques Schott</td>
</tr>
<tr>
<td></td>
<td>Manabu Kunitake</td>
</tr>
<tr>
<td></td>
<td>Luc Decker</td>
</tr>
</tbody>
</table>
INDEX

Absolute measurements ................................................................. 6, 23
Addresses
  Executive Council ................................................................. 47
  GIN Internet ........................................................................ 11
  GIN managers ..................................................................... 11
  INTERMAGNET DVD/CD-ROM distribution office ..................... 18
  INTERMAGNET office ........................................................ 48
  Operations Committee ......................................................... 48
  Satellite operators ............................................................. 20
  Satellite services ............................................................... 21
Adjusted data ........................................................................... 9, 29
Base-44 Coding for GMS ............................................................ 62
Baseline .................................................................................. 6, 23, 24
  Adoption ............................................................................. 25
  Statistics ............................................................................. 25
Baseline Reference Measurement (BRM) ....................................... 29
CD-ROM ................................................................................. 13
  Data encoding .................................................................... 6
  Directory structure ............................................................ 16
  Software ............................................................................. 17
Data
  Condition of use .................................................................. 3
  Distribution .......................................................................... 2
  Formats ............................................................................... 5, 9
  Near real-time ..................................................................... 1
  Quality control ................................................................... 23
  Reported, Adjusted, Definitive ............................................ 9
  Sampling and filtering ........................................................ 5
DATA ENCODING
  DVD/CD-ROM .................................................................... 6, 13, 37-40
  Electronic mail ..................................................................... 6
  Satellite transmission .......................................................... 6, 53
Data formats
  Annual mean values .............................................................. 43
  Baselines ............................................................................. 67, 69
  Magnetic indices ................................................................ 10
  Minute values ...................................................................... 10, 63, 65
  Satellite ............................................................................... 51
  Spreadsheet compatible ....................................................... 71
Definitive data ........................................................................... 9, 29
Directory structure (DVD/CD-ROM) .......................................... 16, 41
Distribution office (DVD/CD-ROM) ........................................... 18
DVD/CD-ROM
Archive format IAFV1.00 ................................................. 15, 40
Archive format IAFV1.10 ................................................. 15, 39
Archive format IAFV2.00 ................................................. 14, 38
Archive format IAFV2.10 ................................................. 13, 37
Data encoding ........................................................... 6, 13
Data inclusion ............................................................ 2
Directory structure ...................................................... 16, 41
Distribution office ...................................................... 18
Map screen ............................................................... 17
Storage requirements .................................................. 16
Electronic mail ............................................................ 6
Executive Council ....................................................... 4, 47, 87
Files (DVD/CD-ROM) ................................................... 16
Filtering ................................................................. 5
Coefficients ............................................................... 77
Flags ..................................................................... 29
Geomagnetic Information Nodes
Definition ................................................................. 1
GIN ................................................................... 29
Definition ................................................................. 1
Description ............................................................... 9
Locations ................................................................. 9
User access ............................................................... 10
GIN Internet Addresses .................................................. 11
GIN manager addresses ................................................ 11
GMS .................................................................... 19, 61
GOES ................................................................... 19, 57
History of INTERMAGNET ..................................................... 1
IAFV1.00 ................................................................ 15, 40
IAFV1.10 ................................................................ 15, 39
IAFV2.00 ................................................................ 14, 38
IAFV2.10 ................................................................ 13, 37
IAGA2002 .................................................................. 71
IBFV1.20 ................................................................... 69
IBFV2.00 ................................................................... 67
IMFV1.22 .................................................................. 65
IMFV1.23 .................................................................. 63
IMFV2.83 .................................................................. 51
IMO ....................................................................... 29
Definition ............................................................... 2, 5
Technical help for operators ........................................... 2
INSAT ..................................................................... 19
Instrumentation
Minimum requirements ................................................... 5
Recorder ................................................................. 5
Satellite transmission ................................................... 5
<table>
<thead>
<tr>
<th>Topic</th>
<th>Page Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>METEOSAT</td>
<td>19, 58</td>
</tr>
<tr>
<td>Operators</td>
<td>20</td>
</tr>
<tr>
<td>Services</td>
<td>21</td>
</tr>
<tr>
<td>Time Slots</td>
<td>20</td>
</tr>
<tr>
<td>Satellite access</td>
<td>19</td>
</tr>
<tr>
<td>Satellite data encoding</td>
<td>53</td>
</tr>
<tr>
<td>Satellite data format</td>
<td>51</td>
</tr>
<tr>
<td>Satellite transmission</td>
<td>5, 6</td>
</tr>
<tr>
<td>Scalar magnetometer</td>
<td>5</td>
</tr>
<tr>
<td>Scale Factor</td>
<td>53</td>
</tr>
<tr>
<td>Scale Multiplier</td>
<td>53</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>i</td>
</tr>
<tr>
<td>Terminology</td>
<td>29</td>
</tr>
<tr>
<td>Time drift</td>
<td>5</td>
</tr>
<tr>
<td>Time stamp</td>
<td>29</td>
</tr>
<tr>
<td>Timekeeping</td>
<td>5</td>
</tr>
<tr>
<td>Total field differences</td>
<td>25</td>
</tr>
<tr>
<td>User access to GINs</td>
<td>10</td>
</tr>
<tr>
<td>Vector magnetometer</td>
<td>5</td>
</tr>
<tr>
<td>Web Site Address</td>
<td>27</td>
</tr>
<tr>
<td>World Wide Web</td>
<td>27</td>
</tr>
</tbody>
</table>