INTERMAGNET

Technical Reference Manual

Version 4.0 (1999)

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.

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Acknowledgements

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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 was operating 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), Hiraiso (CRL), 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 geomagnetic data will be made available in a timely fashion to participating observatories on media and in formats approved by the INTERMAGNET Executive Council.
8. The collected data will be made available to the scientific community on media and in formats approved by the INTERMAGNET Executive Council. The 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 CD-ROM and will receive in return one copy of the CD-ROM free of charge. Other parties may purchase copies of the CD-ROM at a price to be determined by the INTERMAGNET Executive Council. The proceeds will be used to further the aims of INTERMAGNET.

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 provisional derived indices are provided. They may be retrieved by electronic mail connection with a GIN. Minute values are kept on-line until the annual CD-ROM is available for sale. Archived data may be made available by special arrangement from some GINs. A CD-ROM is provided annually containing definitive data from INTERMAGNET observatories. Technical help for operators of IMOs may also be available by special arrangements through the INTERMAGNET office.

1.7 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.

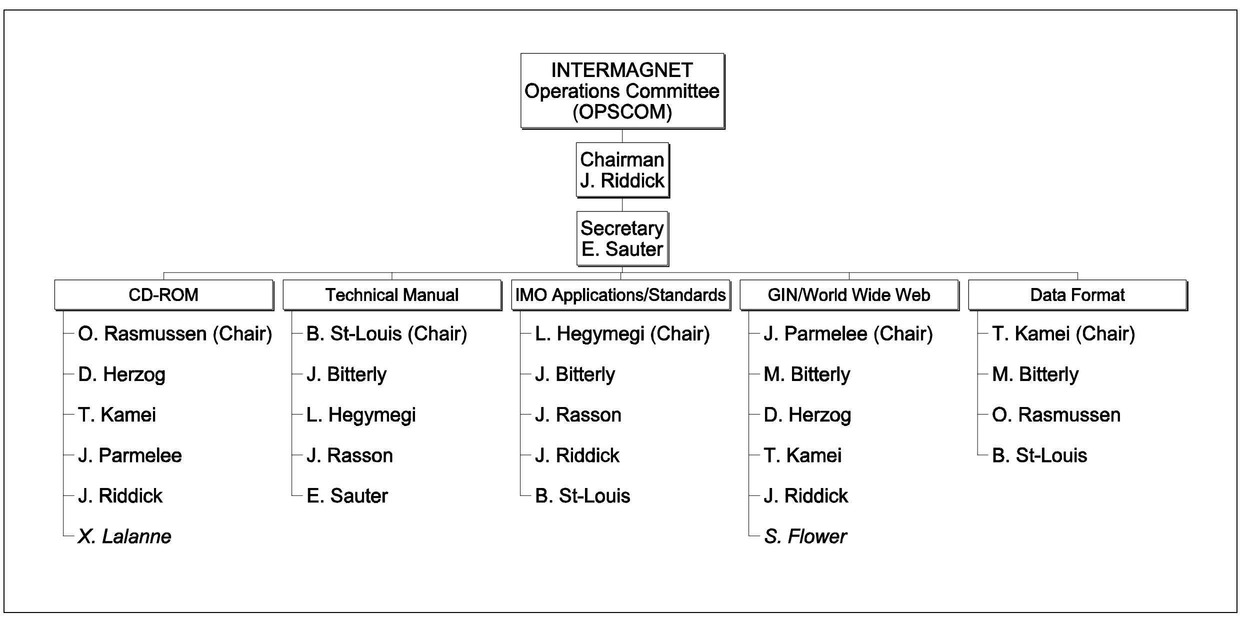
The Operations Committee advises the Executive Council on matters relating to magnetic sensors, data capture and data processing, and on communications options, protocols, etc. The Operations Committee is also responsible for establishing and maintaining standards of operation and uniform data formats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

Executive Council membership:

R.L. Coles	(Canada) (Chairman)
A.W. Green Jr.	(USA) (Secretary)
J.L. Le Mouël	(France)
D.J. Kerridge	(UK)

Operations Committee membership:

J. Bitterly	(France)
M. Bitterly	(France)
L. Hegymegi	(Hungary)
D. Herzog	(USA)
T. Kamei	(Japan)
J. Parmelee	(Canada)
O. Rasmussen	(Denmark)
J. Rasson	(Belgium)
J. Riddick	(UK) (Chairman)
B.J. St-Louis	(Canada)
E.A. Sauter	(USA) (Secretary)



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:	6000 nT Auroral & Equatorial 2000 nT Mid 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:	IMFV2.83 or IMFV1.22 (or later)
Definitive data:	to be submitted for inclusion on the CD-ROM
Baseline data:	each component to be submitted for inclusion on the CD-ROM
Filtering:	to INTERMAGNET standard (Section 2.2)

2.2 DATA SAMPLING AND FILTERING

In its Resolution 12 from the 1979 Assembly in Canberra, IAGA has 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:

C0 = 0.00229315	C10 = 0.11972085
C1 = 0.00531440	C11 = 0.10321785
C2 = 0.01115655	C12 = 0.08061140
C3 = 0.02121585	C13 = 0.05702885
C4 = 0.03654680	C14 = 0.03654680
C5 = 0.05702885	C15 = 0.02121585
C6 = 0.08061140	C16 = 0.01115655
C7 = 0.10321785	C17 = 0.00531440
C8 = 0.11972085	C18 = 0.00229315
C9 = 0.12578865	

For a filter output value to be centered on the minute, coefficient C0 is applied 45 seconds before this minute and coefficient C18 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.

2.3 DATA ENCODING FOR ELECTRONIC MAIL TRANSMISSION

Electronic mail transmission of data to a GIN must be done using INTERMAGNET GIN Dissemination Format for Minute Values IMFV1.22 described in Appendix E-3. The SUBJECT field of the electronic mail header will contain, in this order: the filename being sent as defined in IMFV1.22, followed by a space, a 2-number day of the month giving the transmission day, space, 3-letter English month abbreviation, space, 2-number year, space, 2-number hour of transmission in UT, colon, minute of transmission.

for example:

```
Subject:MAR1592.BOU 16 MAR 92 00:10 XXXXX
```

This indicates that a day file containing data from Boulder observatory March 15 is sent on March 16th at 00:10. The time of transmission is useful at the GIN to determine transit times and delays in transfer. A complete day's data is assembled into each IMFV1.22 file.

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 CD-ROM

Definitive data for an IMO is to be provided to INTERMAGNET shortly after the end of each calendar year for inclusion in an annual INTERMAGNET CD-ROM. The format for submission of data appears in Appendix C-1. Samples of baseline data will accompany the definitive data, and will be provided in format IBFV1.11 or later as described in Appendix E-4. Refer to chapter 4 for a general description of the CD-ROM.

2.6 ABSOLUTE MEASUREMENTS

The provision of absolute control at a magnetic observatory normally requires a series of measurements of the absolute values of the geomagnetic field using manually operated instruments. The frequency at which these measurements are made may vary from daily to several times a year, 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 an increasingly common set consists of 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 appears to be 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 outside the absolute building, in an undisturbed area; 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.

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

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

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:

Best, A. and Linthe, H.-J. (eds.) 1998. Proceedings of the VIIth Workshop on Geomagnetic Observatory Instruments, Data Acquisition and Processing, GeoForschungsZentrum Potsdam, Scientific Technical Report STR98/21, 450p.

Coles, R.L. (ed.) 1988. Proceedings of the International Workshop on Magnetic Observatory Instruments; Geological Survey of Canada Paper 88-17, 94 p.

Jankowski, J. and Sucksdorff, C. 1996. Manual on Magnetic Measurements and Observatory Practice, International Association of Geomagnetism and Aeronomy, Boulder, Co., 235 p.

Kauristie, K., Sucksdorff, C., and Nevanlinna, H. (eds.) 1990. Proceedings of the International Workshop on Geomagnetic Observatory Data Acquisition and Processing; Finnish Meteorological Institute, Geophysical Publications No.15, 151 p.

Newitt, L.R., Barton, C.E., and Bitterly, J. 1996. Guide for Magnetic Repeat Station Surveys, International Association of Geomagnetism and Aeronomie, Boulder, Co., 112 p.

Rasson, J.L. (ed.) 1996. Proceedings of the VIth Workshop on Geomagnetic Observatory Instruments, Data Acquisition and Processing, Dourbes, Institut Royal Meteorologique de Belgique, Publication scientifique et technique N. 003., 249 p.

Stuart, W.F.(ed.) 1984. Geomagnetic observatory and survey practice; reprinted from Geophysical Surveys, Vol. 6, nos. 3/4; D. Reidel, Dordrecht/Boston, 464 p.

Wienert, K.A. 1970. Notes on geomagnetic observatory and survey practice; UNESCO, Paris, 217 p.

CHAPTER 3 GEOMAGNETIC INFORMATION NODES - GINs

3.1 DEFINITION

In order that all INTERMAGNET data transfers may be handled efficiently with all received data passed to users as quickly as possible, 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 and store it in a database from which it may be easily obtained by users of INTERMAGNET data.

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.
Hiraiso, Japan	- Hiraiso Solar Terrestrial Research center

Full GIN addresses are given at the end of this chapter. All sites are equipped with satellite receiving equipment and 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. Using the METEOSAT link, data reach the GIN within 72 minutes of recording. An alternative method, for observatories not equipped with satellite transmission equipment, is to input data to a GIN using computer 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 INTERMAGNET Format IMFV2.83 or INTERMAGNET GIN Dissemination Format for Minute Values IMFV1.22, or subsequent versions. The IMFV2.83 format is used for data transmitted through a satellite link, the IMFV1.22 format for data input through a telephone network or on a computer 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 V1.22 format and to designate them as REPORTED data.

At a GIN, the IMFV1.22 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 have missing values. When ADJUSTED data are available, REPORTED data are removed from online access.

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 CD-ROM is available for sale. 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 IMFV1.22 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 CD-ROM.

3.3 DATA TRANSMISSION FORMATS

In order that all INTERMAGNET data relayed from 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 are in these formats, and a GIN will not accept data from any INTERMAGNET participant unless they adhere strictly to the defined formats.

1) IMFV1.22 INTERMAGNET GIN

DISSEMINATION FORMAT FOR MINUTE VALUES

This defines the format in which observatory minute data may be input to a GIN by electronic mail and it is the format that will be used by GINs to respond to all requests for data. This format is fully defined and described in Appendix E-3.

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. Data for each of these observatories are maintained on-line until the CD-ROM is available for sale.

The complete INTERMAGNET data set for all participating observatories is very large. Since each IMFV1.22 observatory day file is 50K bytes, one day of data from 30 observatories requires 1.5 Mbytes storage. This fact, coupled with the fact that inter-GIN data transfers using E-Mail can take a considerable amount of time, means that it is not practical or efficient for each GIN to hold the data for every INTERMAGNET observatory. Appendix B-2 contains a list of all INTERMAGNET observatories and the respective GINs where the data are stored.

Any data request should be made directly to the GIN responsible for the observatory of interest (Appendix B-2). This request can be made using E-Mail, telephone or fax. Normally, data are supplied by the GIN to the customer using E-Mail. A reply E-Mail address should be included with a data request. Recipients of INTERMAGNET data files should ensure that their system is capable of accepting the data files being requested from a GIN. If the size of a data file cannot be accepted by the recipient's computer and the file is returned to the GIN, operational difficulties can occur.

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.

Requests for data from a GIN will often be made on a daily basis, i.e. a user requests that data from a particular observatory, or group of observatories be sent, via E-Mail, once a day as soon as the data become available at the GIN. If a user requires many days of data from more than one observatory, and these data are not current, the data request is best met by copying the data to floppy disk and mailing it to the user. The minimum data file contains 1 day of data. Requests for partial days are not supported. All data output from a GIN in response to a customer enquiry will be in ASCII format and normally transmitted using E-Mail.

3.4.1 GIN MESSAGE FORMATS FOR DATA REQUESTS

SUBJECT	MESSAGE
SEND INFORMATION	(blank)
SEND DATA-DIRECTORY	SSS <MON><DD><YY> Number of Days #Comment lines are allowed
SEND MINUTE-MEANS	SSS<MON><DD><YY> Number of days #Comment lines are allowed

where USERNAME = The password issued by some GIN's (e.g. Ottawa) to allow access to the system. If a password is not required, enter your own username.
SSS = IAGA Station Code
<MON> = Start month for requested data (e.g. Aug.)
<DD> = Start day of requested data (e.g. 12)
<YY> = Year of data collection (e.g. 93).

Explanation of Data and Information requests made through e-mail to a GIN:

SEND INFORMATION — Information on GIN access, data file format, a list of observatories and how to extract data.

SEND DATA-DIRECTORY — Lists data available in the GIN for a specified observatory. Minutes values are kept on-line until the annual CD-ROM is available for sale. Older data may be recovered from archives by special arrangement.

SEND MINUTE-MEANS — Extracts from the GIN database and transmits a day file of minute-means data from a specified observatory.

Other options available from certain GIN's include indices, magnetogram plots and data reduction software (INTERMAGNET Users Software Library). Details of these facilities and how to access them are available from the SEND INFORMATION package.

3.4.2 EDINBURGH GIN ACCESS

To obtain a text file describing how to access the GIN, E-Mail the Edinburgh GIN at address:
Internet e_gin@mail.nmh.ac.uk

Using the message formats given in 3.4.1, information and data may be extracted from the GIN.

To request INFORMATION about the GIN via Internet:

```
E-mail to:   e_gin@mail.nmh.ac.uk
subject:     send information
```

To request 5 days of data for LERwick and ESKdalemuir starting on September 5, 1994, via Internet:

```
E-mail to:   e_gin@mail.nmh.ac.uk
subject:     send minute-means
message:     #Comment line beginning with '#'
             ler sep0594 5
             esk sep0594 5
             #End of data request
```

3.4.3 OTTAWA GIN ACCESS

To obtain a text file describing how to access the GIN, E-mail the Ottawa GIN at address:
Internet ottgin@geolab.nrcan.gc.ca

Using the message formats given in 3.4.1, information and data may be extracted from the GIN.

To request INFORMATION about the GIN via Internet:

```
E-mail to:   ottgin@geolab.nrcan.gc.ca
subject:     send information
```

To request 5 days of data for OTTawa and MEAnook starting on December 3, 1994, via Internet:

```
E-mail to:   ottgin@geolab.nrcan.gc.ca
subject:     send minute-means
message:     ott dec0394 5
             mea dec0394 5
```

3.4.4 HIRAISO GIN ACCESS

To obtain a text file describing how to access the GIN, E-Mail the Hiraiso GIN at address:
Internet hiraiso-gin@crl.go.jp

Using the message formats given in 3.4.1, information and data may be extracted from the GIN.

To request INFORMATION about the GIN via Internet:

```
E-mail to:   hiraiso-gin@crl.go.jp
subject:     send information
```

To request 5 days of data for KAKioka and MeMamBetsu starting on March 1, 1995, via Internet:

```
E-mail to:   hiraiso-gin@crl.go.jp
subject:     send minute-means
message:     kak mar0195 5
             mmb mar0195 5
```

3.4.5 KYOTO GIN ACCESS

To obtain a text file describing how to access the GIN, E-Mail the Kyoto GIN at address:
Internet kyoto-gin@swdcdb.kugi.kyoto-u.ac.jp

Using the message formats given in 3.4.1, information and data may be extracted from the GIN.

To request INFORMATION about the GIN via Internet:

```
E-mail to:   kyoto-gin@swdcdb.kugi.kyoto-u.ac.jp
subject:     send information
```

To request 5 days of data for KAKioka and MeMamBetsu starting on March 1, 1995, via Internet:

```
E-mail to:   kyoto-gin@swdcdb.kugi.kyoto-u.ac.jp
subject:     send minute-means
message:     kak mar0195 5
             mmb mar0195 5
```

3.4.6 PARIS GIN ACCESS

To obtain a text file describing how to access the GIN, E-Mail the Paris GIN at address:
Internet par_gin@ipgp.jussieu.fr

Using the message formats given in 3.4.1, information and data may be extracted from the GIN.

To request INFORMATION about the GIN via Internet:

E-mail to: par_gin@ipgp.jussieu.fr
subject: send information

To request 3 days of data for KOUrou starting on February 1, 1995, via Internet:

E-mail to: par_gin@ipgp.jussieu.fr
subject: send minute-means
message: kou feb0195 3

3.4.7 GOLDEN GIN ACCESS

To obtain a text file describing how to access the GIN, E-Mail the Golden GIN at address:
Internet gol_gin@gldfs.cr.usgs.gov

Using the message formats given in 3.4.1, information and data may be extracted from the GIN.

To request INFORMATION about the GIN via Internet:

E-mail to: gol_gin@gldfs.cr.usgs.gov
subject: send information

To request 3 days of data for FReDericksburg starting on February 10, 1996 and 4 days of data for SITka starting on April 12, 1996, via Internet:

E-mail to: gol_gin@gldfs.cr.usgs.gov
subject: send minute-means
message: frd feb1096 3
sit apr1296 4

3.5 GIN MANAGER ADDRESSES

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

USGS - USA:
Donald C. Herzog
U.S. Geological Survey
Box 25046 MS 968
Denver Federal Center
Denver, Colorado 80225-0046
USA
Telephone: 1-303-273-8487
Fax: 1-303-273-8450
Internet: gol_manager@gldfs.cr.usgs.gov

GSC - Canada:
Larry Newitt
Geological Survey of Canada
Geophysics Division
7 Observatory Crescent
Ottawa, Ontario
CANADA
K1A 0Y3
Telephone: 1-613-837-7915
Fax: 1-613-824-9803
Internet: ottmanager@geolab.nrcan.gc.ca

BGS - Scotland:
Simon M. Flower
Geomagnetism Group
British Geological Survey
Murchison House
West Mains Road
Edinburgh EH9 3LA
UK
Telephone: 44-131-667-1000
Fax: 44-131-668-4368
Internet: e_ginman@mail.nmh.ac.uk

IPG - France:
Michèle Bitterly
Observatoire Magnétique
Carrefour des 8 routes
F-45340 Chambon la Forêt
FRANCE
Telephone: 33-2-38-33-9502
Fax: 33-2-38-33-9504
Internet: p_ginman@ipgp.jussieu.fr

Kyoto University - Japan:
Toyohisa Kamei
WDC-2 for Geomagnetism
Faculty of Science
Kyoto University
Kyoto 606
JAPAN
Telephone: 81-75-753-3937
Fax: 81-75-722-7884
Internet: imagmanager@swdcdb.kugi.kyoto-u.ac.jp

CRL - Japan:
Manabu Kunitake
Hiraiso Solar Terrestrial Research Center
Communications Research Laboratory
3601 Isozaki, Hitachinaka
Ibaraki 311-1202
JAPAN
Telephone: 81-292-65-9710
Fax: 81 292-65-9720
Internet: imagmanager@crl.go.jp

3.6 GIN INTERNET ADDRESSES

ottgin@geolab.nrcan.gc.ca
par_gin@ipgp.jussieu.fr
gol_gin@gldfs.cr.usgs.gov
e_gin@mail.nmh.ac.uk
hiraiso-gin@crl.go.jp
kyoto-gin@swdcdb.kugi.kyoto-u.ac.jp

CHAPTER 4 THE INTERMAGNET 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 four 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 base lines and other processing procedures) and samples of baseline data to be included on the annual INTERMAGNET CD-ROM.

The INTERMAGNET CD-ROM only contains data from either participating or affiliated observatories. Participating observatories are those that meet the INTERMAGNET standards and also report their data to a GIN within 72 hours of recording. Affiliated observatories are those that meet the INTERMAGNET standards, except for the time constraint of providing data to a GIN, and commit to become an IMO within 2 years. 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 CD-ROMs also contain baseline data for the year for each observatory in the form of text and plots. Appendix C-4 of this manual provides a list of observatories contributing to the CD-ROM, and Appendix C-5 gives a map showing their locations.

The CD-ROM itself conforms to the ISO 9660 standards, and only requires a 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 THE CD-ROM DATA STRUCTURE

The data on the CD-ROM 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. Appendix C-1 provides a schematic representation of the record structure. Words 1-10 contain header information including a 3-letter observatory identification (ID) code, the year concatenated with the day of the year, co-latitude, longitude, elevation, orientation, originating organization, a D-conversion factor, data quality, and instrumentation. 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).

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".

Words 11-15 are reserved for future use and padded with zeros. 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 H,D,Z,F or X,Y,Z,F) for the day. The values 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 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, and word 5885 contained the equivalent daily amplitude index (Ak). 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 true K-Index values and word 5885 still contains the Ak value. The last 3 words (5886-5888) are reserved for future use. Missing data for minute, hour, and day values are stored as "999999". Missing K-Index and Ak values are stored as "999".

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 memory, so the 41 observatories on the 1991 INTERMAGNET CD-ROM require more than 352 Mb of storage space. The actual size of the 1991

CD-ROM is 354,992,128 bytes in 607 files and 47 directories.

4.4 INTERMAGNET CD-ROM DIRECTORY STRUCTURE

The files on the INTERMAGNET CD-ROM are set up in a particular directory structure. This structure for the 1991 CD-ROM is shown in Appendix C-2. The most important directory is labeled "MAGyear" where "year" is the year of data for the CD-ROM - for example MAG1991 for the 1991 data. This is important because if this directory (and its contents) are stored on a hard drive, the software will treat the hard drive as though it were a CD-ROM. In other words, the software looks for the directories MAG1991, MAG1992, and so on, rather than a CD-ROM device per se. This was done to enable users without a CD-ROM reader to use the access software to view the data.

Also in the root directory is an "XTRAS" directory that contains the files "STRUCTUR.DAT" and "PRNSTRUC.EXE". The STRUCTUR.DAT file provides a schematic of the data structure for the records on the CD-ROM (the same one shown in Appendix C-1), and the PRNSTRUC.EXE file enables the user to obtain a printout (hard copy) of this record structure.

The root directory also contains the "README.TXT" and "README.EXE" files. The README.TXT file is an ASCII file describing the CD-ROM and information about it, and the README.EXE file is an executable version of the README.TXT file that allows the user to scrool back and forth through the information.

Starting with the 1994 CD-ROM, an "ERRATA" directory was added that contains information and data pertaining to corrections to previous CD-ROMs. For example, the 1994 ERRATA directory contains corrected Mean Hourly Value (MHV) data for some of the Canadian observatories for 1991. Also included on the 1994 CD-ROM is an "INSTALL.EXE" file that enables the user to install the software on their computer; "IMAG##.EXE", which is the access software program itself and where ## is the version number; "GMAG.CFG", which is a configuration file used by the PREFERENCES option of the software (see Section 4.5 below); and a "BROWSE.COM" file used by the README.EXE executable.

The contents of the "MAGyear" directories can be described using mag1991 as an exemple: The MAG1991 directory contains a sub-directory for each observatory identified by its 3-letter ID code. In addition, there are sub-directories labelled "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 labelled by a 3-letter country ID with the PCX extension, and one labelled "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 labelled 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.

For those observatories that provided an ASCII K-Index file, this sub-directory also contains that file labelled as XXXYRK.DKA, where the XXX is the 3-letter observatory ID, the YR is the 2-character year value, the K indicates a K-Index file, and the DKA extension indicates that the data were generated from a digital algorithm and is an ASCII file. These 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 CD-ROM. Since 1992, each observatory also supplies a baseline value file XXXYR.BLV, where BLV is the extension for baseline files. The format of this file is described in Appendix E-4. These baseline values are also stored as graphics format in XXXYR.PCX, where PCX is the extension. Since 1994, each observatory also supplies a yearmean file YEARMEAN.XXX listing annual mean values for the observatory since 1980. The format of this file is described in Appendix C-3.

4.5 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 **S**ave the graphics in the form of *.PCX files that can then be imported into other programs that accept the PCX format; and also **S**ave 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 "↑" and "↓" 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 ↑, ↓, 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 "↑" and "↓" 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 **V**(iew map) key once the particular country has been chosen. Also, an **A**(bout) 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 **C**(omponent) option (Hot Key "C") from the menu bar. While in the Component mode, the **T**(oggle) 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. **P**(rint) and **S**(ave) options are also available for both graphics and text modes. Starting with the 1992 CD-ROM, a Base(**l**)ine 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 **B**(eginning day) choice that resets the output to the beginning of the selected date-range, a **F2**(Flow) chart of the software program that indicates where the user is within the program and what outputs are available, and a **R**(escale) 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..

The CD-ROM, software and documentation may be obtained from:

INTERMAGNET sales office
Département des Observatoires IPGP, B89
4 Place Jussieu
75252 Paris Cedex 05
FRANCE

Tel: 33-2-3833-9501
Fax: 33-2-3833-9504
Internet: imso@ipgp.jussieu.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 tranmissions. 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 data message is then retransmitted, at a different frequency, by EUMETSAT Ground Center, along with meteorological facsimile messages, back to the satellite for retransmission to a GIN. This retransmission process can add a 5 minute delay between the observatory transmitting its message and the GIN receiving the data.

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 relayed 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. Any 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-3 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 73 04
INTERNET: ops@eumetsat.de

Those whose potential IMOs would be serviced by METEOSAT are advised to first contact the PARIS or EDINBURGH GIN operators 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: jabeyta@selvax.sel.bldrdoc.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.

3) GMS

Contact through:

Toyohisa Kamei
WDC-C2 for Geomagnetism
Faculty of Science
Kyoto University
Kyoto 606
JAPAN
Telephone: 81-75-753-3937
FAX: 81-75-722-7884
INTERNET: toyo@kugi.kyoto-u.ac.jp

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 will accompany data contained on INTERMAGNET CD-ROMs. A graphic display of baselines and differences in computed and recorded total field values will be available to users for stations on the INTERMAGNET 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:

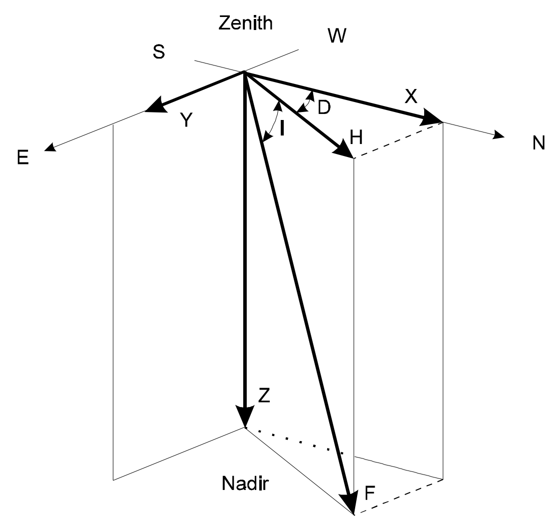
- orientation of variometer sensors
- stability of variometer piers
- filter techniques used in digitizing values
- temperature coefficients of variometer sensors and electronics
- background noise of sensors and electronics
- orthogonality of variometer sensors
- application of absolute controls

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 (ordinate) values. Absolute values of the Earth's magnetic field are measured by an observer and the accuracy and precision of the absolute values depend on several factors:

- observer skill, and absence of bias
- 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).



D - Declination
Y - East-West Component
I - Inclination
Z - Vertical Intensity
H - Horizontal Intensity
F - Total Intensity
X - North-South Component

N - Geographic North
S - South
E - East
W - West

Figure 1 - Geomagnetic Components

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:

$$W_B(k) = W_O(i{:}j) - [W_S(k) * W_M(i{:}j)]$$

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).

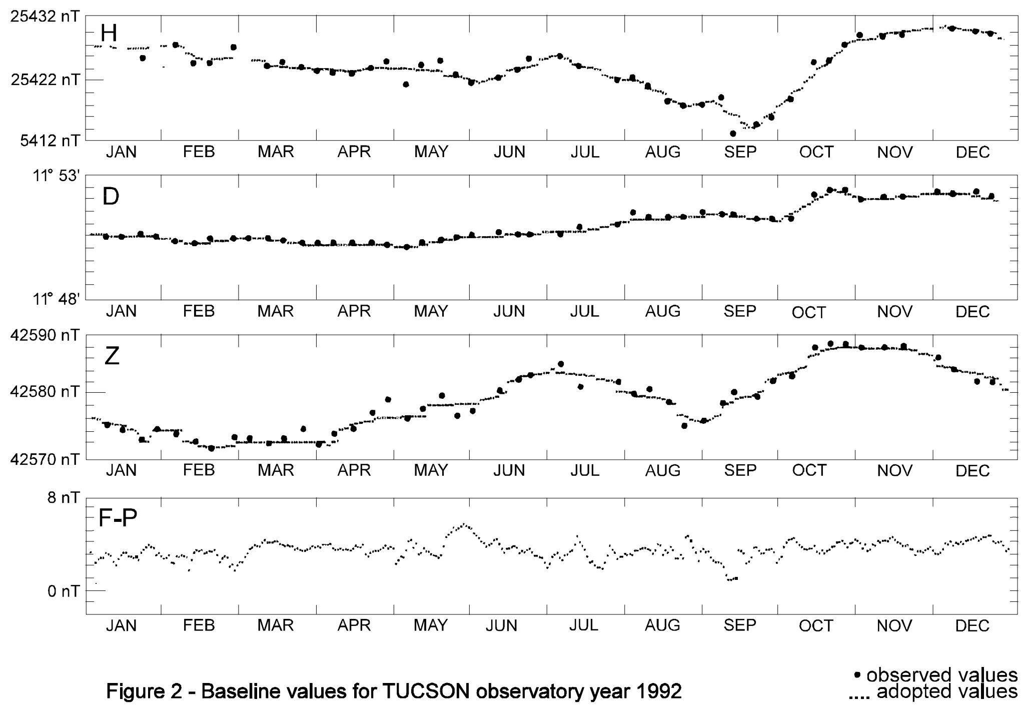


Figure 2 - Baseline values for TUCSON observatory year 1992

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 IBFV1.11, (Appendix E-4). The format includes a section for comments pertaining to dates and times of baseline adjustments or changes in instrumentation. These files will be transmitted annually to INTERMAGNET along with 1-minute data for CD-ROM production.

If the baseline is adopted by computer, statistics may be generated to produce confidence limits for the adopted baseline. 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 (filled circles) and adopted baseline values (dots) for magnetic field components H, D, and Z for Tucson observatory during 1992. 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 oriented to measure components XYZ is:

$$(F\text{-}P)_i = [(BX_i+X_i)^2+(BY_i+Y_i)^2+(BZ_i+Z_i)^2]^{1/2} - F_i + PDF$$

and for HDZ orientation,

$$(F\text{-}P)_i = [(BH_i+HN_i)^2+HE^2+(BZ_i+Z_i)^2]^{1/2} - F_i + PDF$$

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.
- HN - is the vector field of the horizontal intensity recorded by the H sensor, as shown in figure 3.
- HE - is the vector field of the horizontal intensity recorded by the D sensor. The change in declination (δD) is relative to the declination of the H sensor at orientation (D_o)

D_o = D_i -ATAN[$HE_i/(BH_i+HN_i)$].
D_i = absolute observed declination

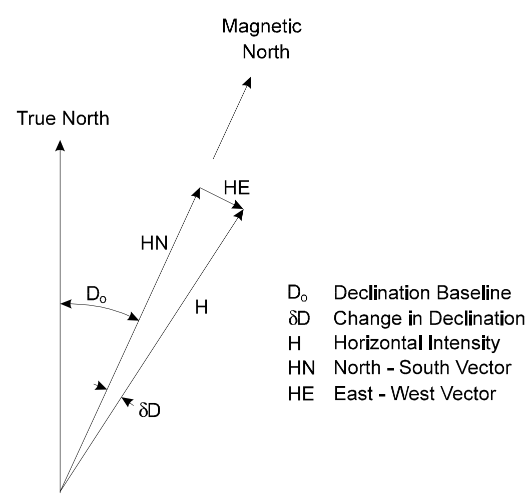


Figure 3 - Component descriptions for baselines

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 (ΔX, ΔY, ΔZ) 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 (ΔY) and Z (ΔZ), then the minimum detectable error that might be attributed to the X component would be: $\Delta X = F\,\Delta F/X$. 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, it's structure and it's 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 CD-ROM of Definitive Data, and the Technical Reference Manual. The INTERMAGNET application form can also be obtained from the web site.

7.2 MIRROR SITES

INTERMAGNET web site address is:
www.intermagnet.org

INTERMAGNET hosts 5 mirror sites around the world. The site addresses and locations are as follows:

www.geolab.nrcan.gc.ca/intermagnet
- Ottawa, Canada (Eastern North America)

obsmag.ipgp.jussieu.fr/INTERMAGNET
- Paris France

swdcdb.kugi.kyoto-u.ac.jp/intermagnet
- Kyoto, Japan

www.gsrg.nmh.ac.uk/intermagnet
- Edinburgh, United Kingdom

geomag.usgs.gov/intermagnetusa
- Golden Colorado (Western North America)

APPENDIX A-1

INTERMAGNET TERMINOLOGY

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, may contain spikes and 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 CD-ROM is available for sale. 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 CD-ROMS.

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 recording station that measures the absolute values of the geomagnetic field on a regular and frequent basis, and that has a degree of permanence that exceeds a few years (capable of producing a time series of annual values for secular variation studies).

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 ASCII 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 Appendices 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).

APPENDIX B-1

OBSERVATORIES PARTICIPATING IN INTERMAGNET (December 1999)

OBSERVATORY		GEOGRAPHIC		PLATFORM	SATELLITE				
ID3		LAT	LON	ADDRESS	CH	S	EL	AZI	ORG
AAE	Addis Ababa	9.03	38.77	1658E15E	11	M	44	259	IPGP/AAU
ABG	Alibag	18.62	72.87	E-MAIL					IIG
ABK	Abisko	68.36	18.82	E-MAIL					GSS
AMS	Martin de Vivies	-37.80	77.57	161CF4CE	11	M	1	278	EOST
API	Apia	-13.80	-171.78	E-MAIL					MAFFM
AQU	L'Aquila	42.38	13.32	E-MAIL					INDG
ASP	Alice Springs	-23.77	133.88	E-MAIL					AGSO
BDV	Budkov	49.07	14.02	E-MAIL					CAS
BEL	Belsk	51.84	20.79	E-MAIL					PAS
BFE	Brorfelde	55.63	11.67	E-MAIL					DMI
BLC	Baker Lake	64.33	-96.03	75C3644C	27	E	16	198	GSC
BMT	Beijing Ming Tombs	40.30	116.20	????????	??	?	??	???	CHAS
BNG	Bangui	4.43	18.56	161E2752	11	M	68	257	IRD
BOU	Boulder	40.14	-105.24	75C2D538	26	W	43	190	USGS
BRW	Barrow	71.32	-156.62	75C172CE	26	W	9	157	USGS
BSL	Bay St. Louis	30.21	-89.38	75C236CA	27	E	47	220	USGS
CBB	Cambridge Bay	69.10	-105.00	75C351D6	27	E	12	187	GSC
CLF	Chambon La Forêt	48.02	2.27	E-MAIL					IPGP
CMO	College	64.91	-147.86	75CO6342	26	W	16	166	USGS
CNB	Canberra	-35.32	149.36	75C2BODE	26	W	3	82	AGSO
CZT	Port Alfred	-51.40	51.90	163B57EC	11	M	14	302	EOST
DLR	Del Rio	29.41	-100.92	75C301AA	27	E	39	234	USGS
DRV	Dumont d'Urville	-66.37	140.01	0580EC	82	G	??	???	EOST
ESK	Eskdalemuir	55.32	-3.20	16176204	21	M	27	176	BGS
EYR	Eyrewell	-43.42	172.35	E-MAIL					IGN
FCC	Fort Churchill	58.77	-94.10	75C3773A	27	E	22	201	GSC
FRD	Fredericksburg	38.21	-77.37	75C21026	27	E	33	228	USGS
FRN	Fresno	37.09	-119.72	75C2F3D4	27	E	46	167	USGS
FUR	Furstenfeldbruck	48.17	11.28	E-MAIL					UMUN
GDH	Godhaven	69.25	-53.53	E-MAIL					DMI
GNA	Gnangara	-31.78	115.95	E-MAIL					AGSO
GUA	Guam	13.58	144.87	E-MAIL					USGS
GUI	Guimar-Tenerife	28.32	-16.43	E-MAIL					IGNS
HAD	Hartland	51.00	-4.48	16177172	21	M	32	174	BGS
HBK	Hartebeesthoek	-25.88	27.71	E-MAIL					CSIR
HER	Hermanus	-34.43	19.23	E-MAIL					CSIR
HLP	Hel	54.61	18.82	E-MAIL					PAS
HON	Honolulu	21.32	-158.00	75C161B8	27	E	33	109	USGS
HRB	Hurbanova	46.86	18.19	E-MAIL					SAS
IQA	Iqaluit	63.75	-68.52	75C0F620	27	E	??	???	GSC
ISK	Istanbul-Kandilli	41.07	29.06	E-MAIL					?????
KAK	Kakioka	36.23	140.18	????????	??	G	??	???	JMA
KOU	Kourou	5.10	-52.70	161E12C8	??	M	30	94	IPGP
LER	Lerwick	60.13	-1.18	162572F6	32	T	22	179	BGS
LNP	Lunping	25.00	121.17	E-MAIL					MTC
LOV	Lovo	59.40	17.80	E-MAIL					GSS
MBO	Mbour	14.38	-16.97	161E01BE	09	M	64	129	IRD
MEA	Meanook	54.62	-113.33	75C32746	27	E	28	178	GSC
MMB	Memambetsu	43.90	144.20	????????	??	G	??	???	JMA
NAQ	Narssarssuaq	61.16	-45.44	E-MAIL					DMI
NCK	Nagycenk	47.63	16.72	164B114A	21	M	48	17	HAS
NEW	Newport	48.26	-117.12	75C2E0A2	27	E	34	173	USGS
NGK	Niemegk	52.07	12.67	16258272	??	M	29	196	GFZP
NUR	Nurmijarvi	57.70	24.70	160F82CE	06	M	21	209	FMI
OTT	Ottawa	45.40	-75.55	75C20350	27	E	27	226	GSC
PAF	Port-aux-Français	-49.35	70.26	165D4660	05	M	4	285	EOST
PBQ	Poste-de-la-Baleine	55.27	-77.75	75C1F4D4	27	E	20	220	GSC
PHU	Phuthuy	21.03	105.95	E-MAIL					IPGP/VNCST
PPT	Pamatai	-17.57	-149.57	E-MAIL					IPGP
RES	Resolute Bay	74.70	-94.90	75C1D236	27	E	6	198	GSC
SBA	Scott Base	-77.85	166.78	E-MAIL					IGNSL
SIT	Sitka	57.06	-135.32	75C28544	26	W	25	180	USGS
SJG	San Juan	18.11	-66.15	75C131C4	27	E	34	253	USGS
SOD	Sodankyla	67.37	26.63	E-MAIL	06	M	12	209	FASL

APPENDIX B-1 (Cont'd)

OBSERVATORIES PARTICIPATING IN INTERMAGNET (December 1999)

OBSERVATORY ID3		GEOGRAPHIC LAT	LON	PLATFORM ADDRESS	SATELLITE CH	S	EL	AZI	ORG
SPT	San Pablo-Toledo	39.55	-4.35	E-MAIL					IGNS
STJ	St. John's	47.60	-52.68	75C1E7AC	27	E	12	246	GSC
SUA	Surlari	45.32	26.25	E-MAIL					GSR
TAM	Tamanrasset	22.80	5.53	162BC510	21	M	63	194	IPGP/CRAAG
TAN	Antananarivo	-18.92	47.55	161D15C6	11	M	32	287	EOST/IOGA
THL	Thule	77.47	-69.23	E-MAIL					DMI
THY	Tihany	46.90	17.89	164B24D0	21	M	47	18	ELGI
TUC	Tucson	32.25	-110.83	75C14754	26	W	44	220	USGS
VIC	Victoria	48.52	-123.42	75C2A3A8	27	E	33	165	GSC
WNG	Wingst	53.74	9.07	E-MAIL					BSH
YKC	Yellowknife	62.46	-114.47	75C312DC	27	E	19	177	GSC

TOTAL 75

AAU	- Addis Ababa University
AGSO	- Australian Geological Survey Organization
BGS	- British Geological Survey
BSH	- Federal Maritime and Hydrographic Agency, Germany
CAS	- Czech Academy of Sciences
CHAS	- Chinese Academy of Sciences
CRAAG	- Centre de Recherche en Astronomie, Astrophysique et Géophysique d'Algérie
CSIR	- Council for Scientific and Industrial Research, South Africa
DMI	- Danish Meteorological Institute
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
GFZP	- GeoForschungsZentrum Potsdam
GSC	- Geological Survey of Canada
GSR	- Geological Survey of Romania
GSS	- Geological Survey of Sweden
HAS	- Hungarian Academy of Science
IGN	- Institute of Geological and nuclear Sciences, New Zealand
IGNS	- Instituto Geografico Nacional, Spain
IGNSL	- Institute of Geological and Nuclear Sciences Limited
IIG	- Indian Institute of Geomagnetism
INDG	- Istituto Nazionale Di Geofisica, Italy
IOGA	- Institut et Observatoire Géophysique d’Antananarivo, Université d’Antananarivo
IPGP	- Institut de Physique du Globe de Paris
IRD	- Institut de Recherche pour le développement, Paris
JMA	- Japan Meteorological Agency
MAFFM	- Ministry of Agriculture, Forestry, Fisheries and Meteorology, New Zealand
MTC	- Ministry of Transportation and Communications, China (Taiwan)
PAS	- Polish Academy of Sciences
SAS	- Slovak Academy of Sciences
UMUN	- University of Munich
USGS	- United States Geological Survey
VNCST	- Vietnam National Center for Science and Technology

APPENDIX B-2

OBSERVATORY DATA COLLECTION BY GIN (December 1999)

OBSERVATORY	EDI	PAR	OTT	GOL	HIR	KYO
Abisko		X				X
Addis Ababa		X				
Alibag						X
Alice Springs	X					
Apia	X					
Aquila		X				
Antananarivo	X	X				
Baker Lake			X			
Barrow					X	
Bangui		X	X			
Bay St. Louis				X		
Beijing Ming Tombs						X
Belsk	X	X				
Boulder				X		
Brorfelde	X	X				X
Budkov	X					
Cambridge Bay			X			
Canberra	X					
Chambon La Forêt	X	X				
College				X		
Del Rio				X		
Dumont d'Urville	X	X			X	X
Eyrewell	X					
Eskdalemuir	X	X				
Fort Churchill			X			
Fredericksburg	X			X		
Fresno					X	
Furstenfeldbruck	X	X				
Gnangara	X					
Godhaven	X	X				X
Guam				X		
Guimar-Tenerife		X				
Hartebeesthoek	X					
Hartland	X	X				
Hel	X	X				
Hermanus	X					X
Honolulu	X	X		X		
Hurbanova	X					
Iqaluit			X			
Istanbul-Kandilli	X					
Kakioka	X				X	X
Kourou	X	X				
Lerwick	X					
Lovo	X					X
Lunping						X
Martin de Vivies	X	X				
Mbour	X	X				
Meanook	X		X			
Memambetsu					X	X
Nagycenk	X	X				
Narssarssuaq	X	X				X
Newport				X		
Niemegk	X	X				
Nurmijarvi	X					
Ottawa		X		X		
Pamatai		X				
Phuthuy		X				
Port Alfred	X	X				
Port-aux-Français	X	X				
Poste-de-la-Baleine			X			
Resolute Bay			X			
San Juan				X		
Scott Base	X					
Sitka				X		

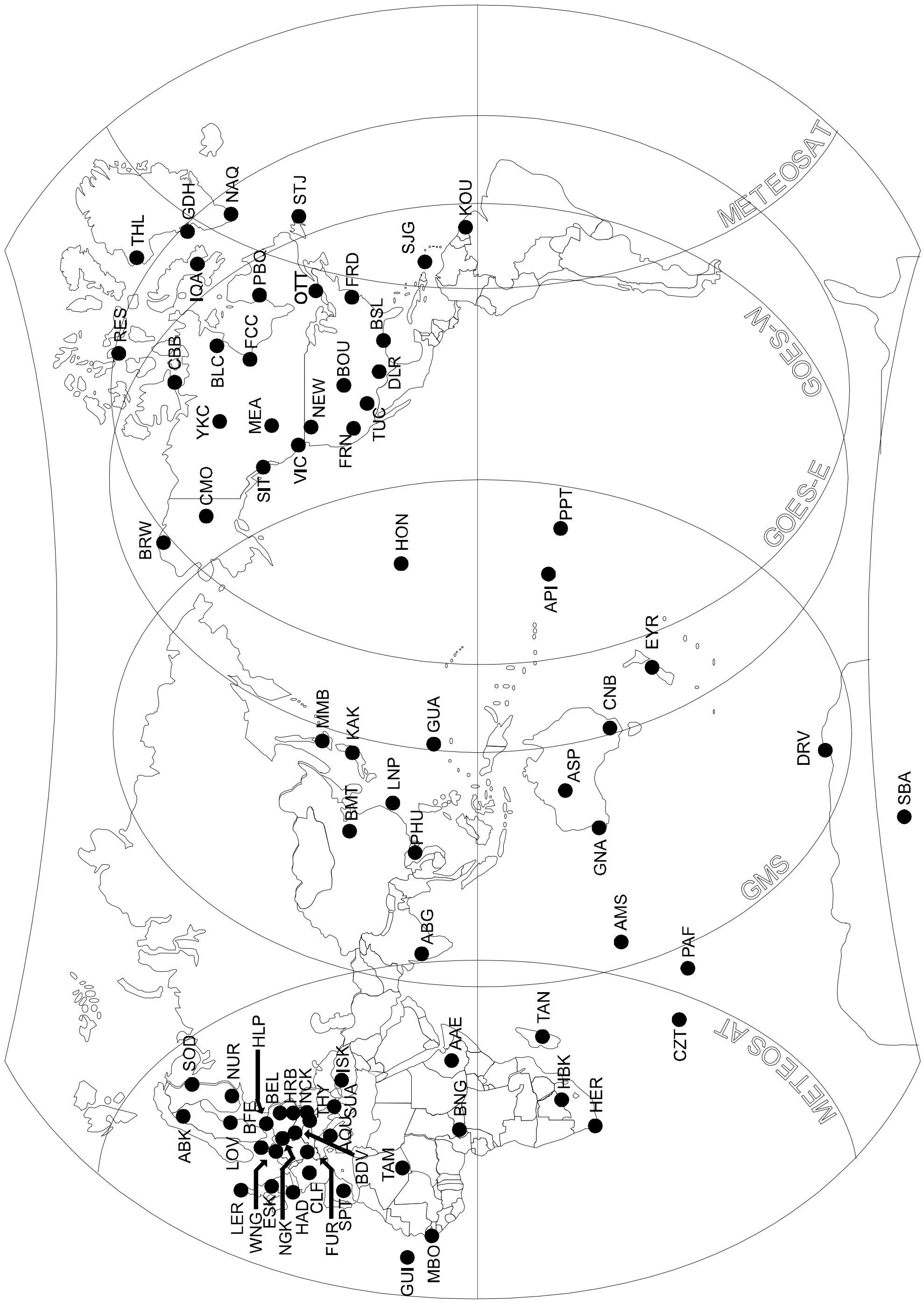
APPENDIX B-2 (Cont'd)

OBSERVATORY DATA COLLECTION BY GIN (December 1999)

OBSERVATORY	EDI	PAR	OTT	GOL	HIR	KYO
Sodankyla	X					
San Pablo-Toledo		X				
St. John's			X			
Surlari		X				
Tamanrasset	X	X				
Thule	X	X				X
Tihany	X	X				
Tucson				X		
Victoria	X		X			
Wingst	X					
Yellowknife			X			
TOTAL 75						
EDI: Edinburgh, UK	45					
PAR: Paris, France		30				
OTT: Ottawa, Canada			11			
GOL: Golden, USA				13		
HIR: Hiraiso, Japan					3	
KYO: Kyoto, Japan						13

APPENDIX B-3

PICTORIAL MAP - SATELLITE FOOTPRINTS AND IMOs OPERATING IN 1999



APPENDIX C-1

CD-ROM BINARY DATA STRUCTURE FORMAT-32 BIT WORDS

Section	WORD	Field	Description
HEADER	1	-Station ID	eg: BOU = HEX(20 42 4F 55)
		-Year||Day Num	eg: 1989001; year 1989, day January 01
		-Co-Latitude	(90° - Latitude) * 1000
		-Longitude	East Longitude * 1000
		-Elevation	elevation in meters above sea level
		-Orientation	eg: XYZF = HEX(58 59 5A 46) (or HDZF)
		-Source	eg: DMI = HEX(20 44 4D 49)
		-D conversion	H/3438*10000 where H=annual mean of H
		-Data Quality	reserved for future use = 0
		-Instrumentation	eg: LC(Linear Core) = HEX(20 20 4C 43) (or RC(Ring Core))
		-K9 value	
			RESERVED FOR FUTURE USE = 0
	16		---Reserved for Each Contributing Institution
ONE MINUTE DATA	17		-1440 mean minute values - element 1 (one day). Missing value = 999999
			-1440 mean minute values - element 2 (one day). Missing value = 999999
			-1440 mean minute values - element 3 (one day). Missing value = 999999
	5776		-1440 mean minute values - element 4 (one day). Missing value = 999999
MEAN HOURLY DATA	5777		-24 mean hourly values - element 1. Missing value = 999999
			-24 mean hourly values - element 2. Missing value = 999999
			-24 mean hourly values - element 3. Missing value = 999999
	5872		-24 mean hourly values - element 4. Missing value = 999999
DAILY MEANS	5873		-daily mean value element 1. Missing value = 999999
			-daily mean value element 2. Missing value = 999999
			-daily mean value element 3. Missing value = 999999
	5876		-daily mean value element 4. Missing value = 999999
K INDICES	5877		-8 digitally derived K-values. Missing value = 999
			-
			-
			-
			-
			-
			-
			-
			RESERVED FOR FUTURE USE = 0
	5888		

APPENDIX C-2

INTERMAGNET CD-ROM DIRECTORY STRUCTURE

```
ROOT DIRECTORY
   │      │
   │      │
   │     README.EXE
   │     README.TXT
   │
   ├────MAG1991
   │      ├────1991MAPS
   │      │        ALL.PCX
   │      │        AUS.PCX
   │      │           :
   │      │           :
   │      │
   │      ├────CTRY_INF
   │      │        CTRYLIST.IDX
   │      │
   │      │        ALLSRN.PCX
   │      │        AUSSRN.PCX
   │      │        CANSRN.PCX
   │      │              :
   │      │              :
   │      │
   │      │        README.ALL
   │      │        README.AUS
   │      │              :
   │      │              :
   │      │
   │      │
   │      ├────AMS
   │      │        AMS91APR.BIN
   │      │        AMS91AUG.BIN
   │      │              :
   │      │              :
   │      │        README.AMS
   │      │        AMS91K.DKA
   │      │
   │      ├────BFE
   │      │        BFE91APR.BIN
   │      │        BFE91AUG.BIN
   │      │              :
   │      │              :
   │      │        README.BFE
   │      │        BFE91K.DKA
   │      │
   │      ├────BLC
   │      │     :
   │      │     :
   │      ├────VIC
   │      │
   │      └────OBSY_INF
   │             91OBSDAT.DBF
   └────XTRAS
          PRNSTRUC.EXE
          STRUCTUR.DAT
```

APPENDIX C-3

IYFV1.01 INTERMAGNET CD-ROM FORMAT FOR YEARMEAN FILE

Magnetic data with 1nT or 0.1min of arc resolution are organized on a year file basis. One file contains annual mean values of the geomagnetic field components since 1980.

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 bloc header

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.
EEEE	: recorded elements. eg:"XYZF" or "HDZF".
NNN	: Note number.
CrLf	: Indicates a Carriage return Line feed.

APPENDIX C-3 (Cont'd)

IYFV1.01 INTERMAGNET 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 mean values were derived

Notes:1. The annual means for 1981 are based on data from the periods JAN 01 - JUL 08 and NOV 03 - DEC 31.
2. The jump on 1990.0 is due to the establishment of a new absolute pillar during 1989.

Sample of a yearmean file

```
                                          ANNUAL MEAN VALUES

                              DUMONT D'URVILLE, DRV, ADELIE LAND, ANTARCTICA

COLATITUDE: 156.665   LONGITUDE: 140.007 E   ELEVATION: 30 m

   YEAR      D         I        H      X      Y      Z      F   * ELE  Note

         Deg min  Deg min     nT     nT     nT     nT     nT

 1980.500 201 48.6 -89  2.3   1177  -1093   -437 -70123  70134 A XYZF
 1981.500 201 13.8 -89   .1   1221  -1138   -442 -70077  70087 A XYZF
 1982.000   0 00.0   0 00.0      6     -9      6    -24     23 J XYZF  1
 1982.500 201 01.0 -88 58.2   1259  -1175   -451 -70027  70039 A XYZF
 1983.500 200 29.8 -88 56.4   1294  -1212   -453 -69972  69984 A XYZF
 1984.500 199 58.9 -88 54.6   1329  -1249   -454 -69924  69937 A XYZF
 1985.500 199 03.7 -88 53.0   1362  -1287   -444 -69872  69886 A XYZF
 1986.500 198 21.6 -88 51.4   1393  -1322   -439 -69831  69845 A XYZF
 1987.500 197 35.8 -88 50.0   1422  -1355   -429 -69799  69814 A XYZF
 1988.500 197 02.0 -88 48.8   1446  -1382   -423 -69764  69779 A XYZF
 1989.500 196 37.8 -88 47.9   1463  -1402   -418 -69731  69746 A XYZF
 1990.500 196 00.5 -88 46.6   1488  -1430   -410 -69700  69716 A XYZF
 1991.500 195 34.6 -88 45.0   1519  -1464   -408 -69682  69699 A XYZF
 1992.500 195 04.8 -88 43.8   1544  -1491   -401 -69652  69670 A XYZF
 1993.500 194 32.0 -88 43.0   1560  -1510   -391 -69628  69646 A XYZF
 1994.500 193 59.3 -88 41.7   1585  -1538   -383 -69620  69638 A XYZF

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

ELE = Elements recorded.

Notes:1.   The jump on 1982.0 is due to the change of absolute
           instruments: the D-I flux replaces the QHM standard.
           A new emplacement of measurement point was adopted
           for X, Y, Z, F measurements. Local gradient involves
           a modification of the observatory reference.
```

APPENDIX C-4

OBSERVATORIES CONTRIBUTING TO INTERMAGNET CD-ROM

OBSERVATORY		GEOGRAPHIC		GEOMAGNETIC*		ORG	1991	1992	1993	1994	1995	1996	1997
ID3		LAT	LON	LAT	LON								
ABK	Abisko	68.36	18.82	65.9	115.4	GSS				X	X	X	X
ABG	Alibag	18.63	72.87	9.9	145.8	IIG							X
ALE	Alert	82.50	-62.35	85.7	168.5	GSC		X			X	X	X
AMS	Martin de Vivies	-37.80	77.57	-46.8	143.3	EOST	X	X	X	X	X	X	X
BDV	Budkov	49.07	14.02	48.8	97.7	CAS				X	X	X	X
BEL	Belsk	51.84	20.79	50.2	105.4	PAS			X	X	X	X	X
BFE	Brorfelde	55.63	11.67	55.5	98.7	DMI	X	X	X	X	X	X	X
BLC	Baker Lake	64.33	-96.03	73.5	320.1	GSC	X	X	X	X	X	X	X
BNG	Bangui	4.43	18.56	-4.6	88.6	IRD			X	X	X	X	X
BOU	Boulder	40.14	-105.24	48.8	319.6	USGS	X	X	X	X	X	X	X
BRW	Barrow	71.32	-156.62	69.3	244.5	USGS	X	X	X	X	X	X	X
BSL	Bay St. Louis	30.21	-89.38	40.4	339.4	USGS	X	X	X	X	X	X	X
CBB	Cambridge Bay	69.10	-105.00	76.7	300.4	GSC	X	X	X	X	X	X	X
CLF	Chambon La Forêt	48.02	2.27	50.0	85.7	IPGP	X	X	X	X	X	X	X
CMO	College	64.70	-147.84	65.1	260.3	USGS	X	X	X	X	X	X	X
CNB	Canberra	-35.32	149.36	-43.1	226.7	AGSO	X	X	X	X	X	X	X
CZT	Port Alfred	-46.44	51.90	-51.4	111.9	EOST	X	X	X	X	X	X	X
DLR	Del Rio	29.41	-100.92	38.6	326.5	USGS	X	X	X	X	X	X	X
DRV	Dumont d'Urville	-66.37	140.01	-74.9	232.0	EOST	X	X	X	X	X	X	X
ESK	Eskdalemuir	55.32	-3.20	58.0	84.1	BGS	X	X	X	X	X	X	X
EYR	Eyrewell	-43.42	172.35	-47.3	254.1	IGN				X	X	X	X
FCC	Fort Churchill	58.77	-94.10	68.3	327.0	GSC	X	X	X	X	X	X	X
FRD	Fredericksburg	38.21	-77.37	48.9	352.8	USGS	X	X	X	X	X	X	X
FRN	Fresno	37.09	-119.72	43.7	304.3	USGS	X	X	X	X	X	X	X
FUR	Furstenfeldbruck	48.17	11.28	48.3	95.1	UMUN					X	X	X
GDH	Godhavn	69.25	-53.53	79.0	34.6	DMI	X	X	X	X	X	X	X
GLN	Glenlea	49.60	-97.10	59.5	323.0	GSC		X	X	X	X	X	X
GNA	Gnangara	-31.78	115.95	-42.4	188.6	AGSO				X	X	X	X
GUA	Guam	13.58	144.87	4.8	215.0	USGS	X	X	X	X	X	X	X
GUI	Guimar-Tenerife	28.32	-16.43	34.0	60.8	IGNS							X
HAD	Hartland	51.00	-4.48	54.1	80.4	BGS	X	X	X	X	X	X	X
HER	Hermanus	-34.43	19.23	-33.9	83.5	CSIR			X	X	X	X	X
HON	Honolulu	21.32	-158.00	21.5	269.0	USGS	X	X	X	X	X	X	X
HRB	Hurbanova	46.86	18.19	45.8	101.2	SAS							X
IQA	Iqaluit	63.75	-68.52	74.4	5.4	GSC						X	X
KAK	Kakioka	36.23	140.18	26.9	208.2	JMA	X	X	X	X	X	X	X
KOU	Kourou	5.10	-52.70	15.2	19.7	IPGP						X	X
LER	Lerwick	60.13	-1.18	62.1	89.5	BGS	X	X	X	X	X	X	X
LNP	Lunping	25.00	121.17	14.6	192.1	MTC					X		X
LOV	Lovo	59.40	17.80	57.9	106.7	GSS	X	X	X	X	X	X	X
MBC	Mould Bay	76.20	-119.40	79.7	261.9	GSC	X	X	X	X	X	X	X
MBO	Mbour	14.38	-16.97	21.3	55.0	IRD			X	X	X	X	X
MEA	Meanook	54.62	-113.33	61.8	304.8	GSC	X	X	X	X	X	X	X
MMB	Memembetsu	43.90	144.20	34.8	210.5	JMA			X	X	X	X	X
NAQ	Narssarssuaq	61.16	-45.44	70.3	39.0	DMI	X	X	X	X	X	X	X
NCK	Nagycenk	47.63	16.72	46.8	100.1	HAS					X	X	X
NEW	Newport	48.26	-117.12	55.1	303.5	USGS	X	X	X	X	X	X	X
NGK	Niemegk	52.07	12.68	51.9	97.9	GFZP			X		X	X	X
NUR	Nurmijarvi	57.70	24.70	55.1	111.8	FMI	X	X	X	X	X	X	X
OTT	Ottawa	45.40	-75.55	56.2	354.6	GSC	X	X	X	X	X	X	X
PAF	Port-aux-Français	-49.35	70.26	-57.2	131.5	EOST	X	X	X	X	X	X	X
PBQ	Poste-de-la-Baleine	55.30	-77.75	66.8	347.3	GSC		X	X	X	X	X	X
PHU	Phuthuy	21.03	105.95	10.4	177.8	IPGP/VNCST						X	X
PPT	Pamatai	-17.57	-149.57	-15.1	284.8	IPGP	X		X	X	X	X	X
RES	Resolute	74.70	-94.90	83.1	287.7	GSC		X	X	X	X	X	X
SBA	Scott Base	-77.85	166.78	-78.8	292.2	IGNSL						X	X
SIT	Sitka	57.06	-135.32	60.3	278.9	USGS	X	X	X	X	X	X	X
SJG	San Juan	18.11	-66.15	28.8	5.6	USGS	X	X	X	X	X	X	X
SOD	Sodankyla	67.37	26.63	63.7	120.5	FASL	X	X	X	X	X	X	X
SPT	San Pablo-Toledo	39.55	-4.35	42.9	76.4	IGNS							X
STJ	St. John's	47.60	-52.68	57.7	23.7	GSC	X	X	X	X	X	X	X
TAM	Tamanrasset	22.79	5.52	24.9	81.4	IPGP/CRAAG			X	X	X	X	X
TAN	Antananarivo	-18.92	47.55	-23.8	114.6	EOST/IOGA			X	X	X	X	X

APPENDIX C-4 (Cont'd)

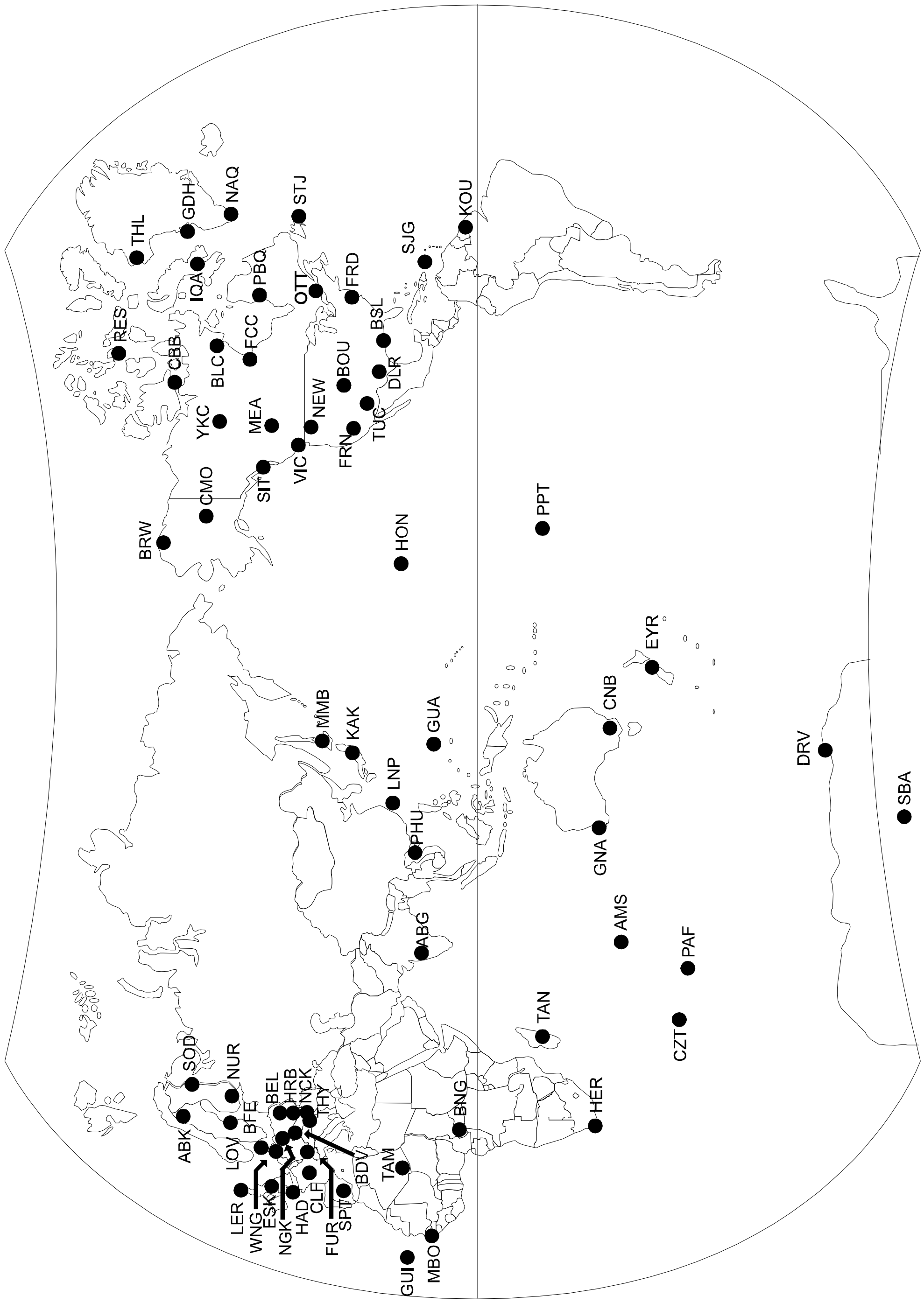
OBSERVATORIES CONTRIBUTING TO INTERMAGNET CD-ROM

OBSERVATORY ID3		GEOGRAPHIC LAT	GEOGRAPHIC LON	GEOMAGNETIC* LAT	GEOMAGNETIC* LON	ORG	1991	1992	1993	1994	1995	1996	1997
THL	Thule	77.47	-69.23	88.2	14.8	DMI	X	X	X	X	X	X	X
THY	Tihany	46.9	17.89	46.0	100.5	ELGI	X	X	X	X	X	X	X
TIK	Tixie Bay	71.58	129.00	61.2	193.2	IZMIRAN	X						
TUC	Tucson	32.25	-110.83	40.2	315.1	USGS	X	X	X	X	X	X	X
VIC	Victoria	48.52	-123.42	54.3	296.4	GSC	X	X	X	X	X	X	X
WNG	Wingst	53.74	9.07	54.1	95.4	BSH				X	X	X	X
YKC	Yellowknife	62.47	-114.47	69.1	292.7	GSC		X	X	X	X	X	X
						TOTAL	41	44	52	56	61	64	69

AGSO - Australian Geological Survey Organization
AAU - Addis Ababa University
BGS - British Geological Survey
BSH - Federal Maritime and Hydrographic Agency, Germany
CAS - Czech Academy of Science
CRAAG - Centre de Recherche en Astronomie, Astrophysique et Géophysique d'Algérie
CSIR - Council for Scientific and Industrial Research, South Africa
DMI - Danish Meteorological Institute
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
GFZP - GeoForschungsZentrum Potsdam
GSC - Geological Survey of Canada
GSS - Geological Survey of Sweden
HAS - Hungarian Academy of Science
IGN - Institute of Geological and nuclear Sciences, New Zealand
IGNS - Instituto Geografico Nacional, Spain
IGNSL - Institute of Geological and Nuclear Sciences Limited
IIG - Indian Institute of Geomagnetism
IOGA - Institut et Observatoire Géophysique d'Antananarivo, Université d'Antananarivo
IPGP - Institut de Physique du Globe de Paris
IRD - Institut de Recherche pour le développement, Paris
IZMIRAN - Institut Zemnovo Magnetisma Ionosfery I Rasprostranyenia Ridiovoln
JMA - Japan Meteorological Agency
MTC - Ministry of Transportation and Communications, China (Taiwan)
PAS - Polish Academy of Sciences
SAS - Slovak Academy of Sciences
UMUN - University of Munich
USGS - United States Geological Survey
VNCST - Vietnam National Center for Science and Technology

APPENDIX C-5

MAP OF OBSERVATORIES CONTRIBUTING TO 1997 CD-ROM



APPENDIX D-1

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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
_____________________________________________________________________

Time stamp of the first sample                              Byte #
Day (1-365/366)                                  12 Bits |1 - 3 *
Minute of the day (0 - 1439)                     12 Bits |1 - 3 *

Offset for C1                                     8 Bits |4
Offset for C2                                     8 Bits |5
Offset for C3                                     8 Bits |6
Offset for C4                                     8 Bits |7

Flags #1                                          8 Bits |8
Flags #2                                          8 Bits |9
                                                         |
Identification:                                          |
  Colatitude in 1/10 degrees (0 - 1800)          12 Bits |10 - 12 *
  East Longitude in 1/10 degrees (0 - 3600)      12 Bits |10 - 12 *
                                                         |
_____________________________________________________________________
                           FREE SPACE 8 BYTES
_____________________________________________________________________
          REFERENCE MEASUREMENT (RM) SPACE OR FREE SPACE 10 BYTES
_____________________________________________________________________
                          MINUTE VALUES 96 BYTES
_____________________________________________________________________
C1 for sample 1                                  16 Bits |31-32
C2 for sample 1                                  16 Bits |33-34
C3 for sample 1                                  16 Bits |35-36
     .                                              .    |  .
     .                                              .    |  .
     .                                              .    |  .
C1 for sample 12                                 16 Bits | 119-120
C2 for sample 12                                 16 Bits | 121-122
C3 for sample 12                                 16 Bits | 123-124
C4 for sample 12                                 16 Bits | 125-126

* See Header Encoding
```

FLAGS #1

```
MSB  (8) & (7) Orientation code  0:  X,Y,Z
                                 1:  H,D,Z
                                 2:  D,I,F
                                 3:  Other
```

Orientation Code	Component 1	Component 2	Component 3	Component 4
0	X	Y	Z	F
1	H	D	Z	F
2		D	I	F
3	.	. (OTHER)	.	.

```
     (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
```

MSB | | | | | | | LSB

Orientation	Code	Scale factor	Scale factor	Scale factor	Scale factor	Filter	Alert Capability
8	7	6	5	4	3	2	1

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)
```

MSB | | | | | | | LSB

SSC	SIP	R M	Reserved	Free for user	Free for user	Free for user	Free for user
8	7	6	5	4	3	2	1

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:

```
Time Stamp Input                            Encoded Output
Least sig. 8 bits of day                    Byte 1
Most sig. 4 bits of day                     Byte 2, four least sig. bits
Least sig. 4 bits of minute                 Byte 2, four most sig. bits
Most sig. 8 bits of minute                  Byte 3

Site Identification Code Input              Encoded Output
Least sig. 8 bits of colatitude             Byte 10
Most sig. 4 bits of colatitude              Byte 11, four least sig. bits
Least sig. 4 bits of east longitude         Byte 11, four most sig. bits
Most sig. 8 bits of east longitude          Byte 12

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

Input fields
     msb                              lsb
     11 10  9  8  7  6  5  4  3  2  1  0

      0  0  0  0  0  0  0  1  1  1  1  0    Day    30   0 1 E (first item)
      0  0  1  0  1  0  1  0  1  1  0  0    Minute 684  2 A C (second item)

Output Encoded field
                     Byte 0            Byte 1              Byte 2

                    0001 1110         1100 0000           0010 1001
HEX                   1    E            C    0              2    A
                    8 lsb Day         4 lsb Minute        8 msb Minute
                                      4 msb Day

The encoded 3 bytes output from this example would be 1ECO2A.
```

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 accomodate 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:

Data(i)	Set of minute values measured in tnT
$D_{pos}(i)$	Minute values shifted by 1048576 to be always positive
D_{max}	Largest $D_{pos}(i)$ of a given component in IMFV2.83 block
D_{min}	Smallest $D_{pos}(i)$ of a given component in IMFV2.83 block
OFF	Offset value
BF	Bias Factor = 8192
SM	Scale Multiplier for sensitivity of encoded data
SF	Scale Factor flag for sensivity of encoded data
E(i)	Set of encoded minute values

Numbers used in this encoding algorithm have been chosen to permit simple binary arithmetic operations:

8192 $= 2^{13}$
57344 $= 2^{16} - 2^{13}$
1048576 $= 2^{20}$
2097151 $= 2^{21} - 1$

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.

$$D_{pos}(i) = Data(i) + 1048576 \qquad (1)$$

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}.

$$OFF = INT\ (D_{min}/BF) \qquad (2)$$

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:

$$SM = INT\ ((D_{max} - OFF*BF)/57344) + 1 \qquad (3)$$

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:

$$E(i) = INT((D_{pos}(i) - OFF*BF)/SM) \qquad (4)$$

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

$$Data(i) = E(i)*SM + OFF*BF - 1048576 \qquad (5)$$

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:

$D_{pos}(i) = Data(i) + 1048576$ (1)
$OFF = INT\ (D_{min}/BF)$ (BF=8192) (2)
$SM = INT\ ((D_{max} - OFF*BF)/57344) + 1$ (3)
$E(i) = INT((D_{pos}(i) - OFF*BF)/SM)$ (4)
$Data(i) = E(i)*SM + OFF*BF - 1048576$ (5)

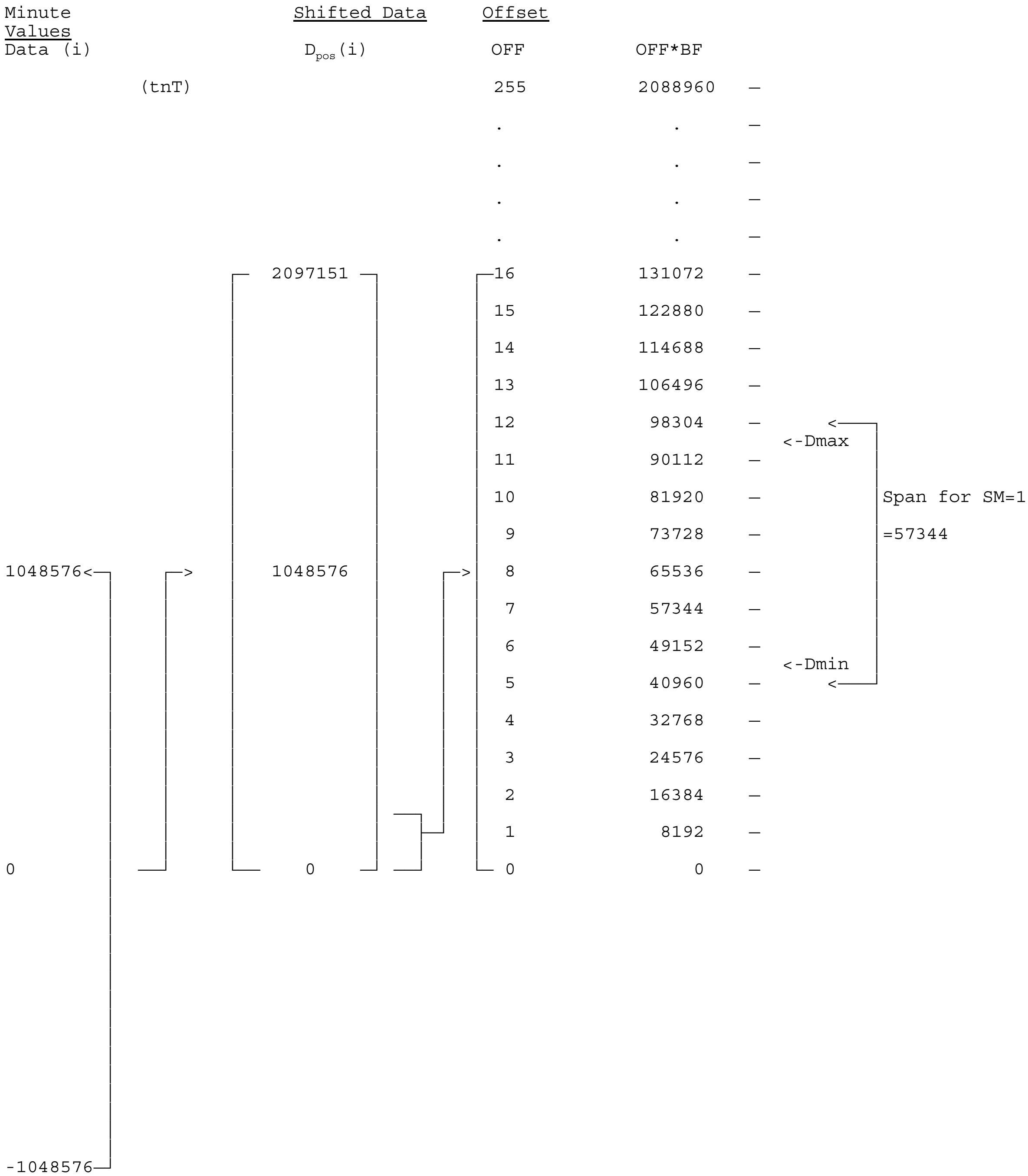
Scale Factor flags are set as follows:

SF	SM
0	1
1	2

NOTE: E(i) set to 65535 (FFFF hex) indicates missing or invalid data.

APPENDIX E-1 (Cont'd)

IMFV2.83 DATA VALUE ENCODING



APPENDIX E-2

SATELLITE CODING EXAMPLES

CODING EXAMPLE FOR GOES SATELLITE

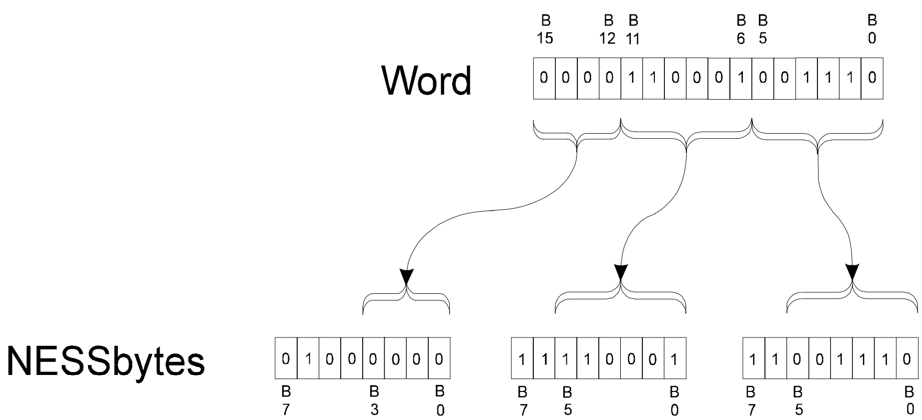
Each block of 126 bytes in IMFV2.83 must be encoded in 189 NESS-BINARY bytes (NESSbytes). NESS-BINARY breaks each pair of source bytes (word) into 3 NESSbytes. If the bits of the source word are B15-B0 with B15 the most significant, then these are placed right-justified in NESSbytes as follows: B15-B12 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 HDZF
INTERMAGNET approved filtering
No alert capability
No RMs
Flag #1: 00111100
Flag #2: 00000000

APPENDIX E-2 (Cont'd)

Minute values of C1, C2, C3, C4

209062 -56 423216 472036
209062 -52 423218 472038
209058 -46 423220 472038
209053 -49 423219 472035
209052 -51 423214 472030
209054 -55 423214 472031
209061 -56 423215 472035
209066 -55 423217 472039
209062 -52 423214 472034
209055 -54 423212 472030
209055 -52 423213 472030
209056 -50 423213 472031

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

```
52  00  2D  99  7F  B3  B9  3C  00  B2  31  8E  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  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
```

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

```
45  C8  40  C2  76  D9  C7  FE  73  FB  E5  70  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  43  40  D5  FE  D0  D3  7A
58  D0  7C  70  DF  43  C8  D5  FE  58  D3  7A  C8  D0  FD  C8  DF  43  D0  D5  FE  58  D3  79  F4  D0  7C  7C  DF
43  4C  D5  FE  4C  D3  79  70  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  7A  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 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 HDZF
INTERMAGNET approved filtering
No alert capability
No RMs
Flag #1: 00111100
Flag #2: 00000000

APPENDIX E-2 (Cont'd)

Minute values of C1, C2, C3, C4

Block # 1: minute 0-11

209062	-56	423216	472036
209062	-52	423218	472038
209058	-46	423220	472038
209053	-49	423219	472035
209052	-51	423214	472030
209054	-55	423214	472031
209061	-56	423215	472035
209066	-55	423217	472039
209062	-52	423214	472034
209055	-54	423212	472030
209055	-52	423213	472030
209056	-50	423213	472031

Block # 2: minute 12-23

209059	-45	423215	472034
209057	-45	423214	472032
209059	-40	423216	472035
209057	-42	423214	472032
209054	-40	423213	472030
209053	-42	423214	472030
209048	-45	423214	472028
209046	-47	423217	472030
209045	-45	423217	472030
209044	-46	423217	472029
209043	-44	423214	472026
209045	-43	423215	472028

Block #3 : minute 24-35

209050	-44	423215	472030
209056	-45	423217	472035
209064	-45	423218	472039
209072	-43	423217	472042
209073	-41	423216	472041
209069	-39	423216	472039
209063	-37	423215	472036
209059	-36	423216	472035
209054	-37	423216	472033
209051	-42	423215	472030
209046	-47	423215	472028
209045	-50	423216	472029

Block # 4: minute 36-47

209041	-56	423214	472025
209044	-58	423215	472027
209044	-60	423215	472027
209049	-57	423217	472031
209056	-54	423217	472035
209063	-48	423217	472038
209068	-45	423217	472040
209070	-42	423216	472040
209072	-40	423217	472042
209070	-38	423216	472040
209065	-40	423215	472037
209063	-41	423215	472036

Block # 5: minute 48-59

209067	-39	423217	472039
209064	-41	423216	472037
209059	-42	423215	472034
209058	-41	423215	472034
209061	-40	423214	472034
209063	-37	423215	472036
209060	-37	423215	472034
209060	-38	423213	472033
209063	-39	423213	472034
209063	-40	423212	472033
209068	-37	423215	472038
209071	-33	423217	472041

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  3C  00  B2  31  8E  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  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  3C  00  B2  31  8E  00  00  00  00  00  00
00  00  00  00  00  00  00  00  00  00  00  00  A3  10  D3  1F
2F  15  E2  13  A1  10  D3  1F  2E  15  E0  13  A3  10  D8  1F
30  15  E3  13  A1  10  D6  1F  2E  15  E0  13  9E  10  D8  1F
2D  15  DE  13  9D  10  D6  1F  2E  15  DE  13  98  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  3C  00  B2  31  8E  00  00  00  00  00  00  00  00
00  00  00  00  00  00  00  00  00  00  9A  10  D4  1F  2F  15
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  AD  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  3C  00  B2  31  8E  00  00  00  00  00  00  00  00  00  00
00  00  00  00  00  00  00  00  91  10  C8  1F  2E  15  D9  13
94  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  E8  13  B0  10  D8  1F  31  15  EA  13
AE  10  DA  1F  30  15  E8  13  A9  10  D8  1F  2F  15  E5  13
A7  10  D7  1F  2F  15  E4  13  52  00  30  99  7F  B3  B9  3C
00  B2  31  8E  00  00  00  00  00  00  00  00  00  00  00  00
00  00  00  00  00  00  AB  10  D9  1F  31  15  E7  13  A8  10
D7  1F  30  15  E5  13  A3  10  D6  1F  2F  15  E2  13  A2  10
D7  1F  2F  15  E2  13  A5  10  D8  1F  2E  15  E2  13  A7  10
DB  1F  2F  15  E4  13  A4  10  DB  1F  2F  15  E2  13  A4  10
DA  1F  2D  15  E1  13  A7  10  D9  1F  2D  15  E2  13  A7  10
D8  1F  2C  15  E1  13  AC  10  DB  1F  2F  15  E6  13  AF  10
DF  1F  31  15  E9  13  00  00  00  00  00  00  00  00  00  00
```

CODING EXAMPLE FOR GMS SATELLITE - Preliminary

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

                            length                  position          frame
Time Day of the year      12 bit    3/4 word       0 word-0.75
     minute of the day    12 bit    3/4 word     0.75word-1.5
offset C1                           1/2 word     1.5 word-2.0
offset C2                           1/2 word     2.0 word-2.5
offset C3                           1/2 word     2.5 word-3.0
offset C4                           1/2 word     3.0 word-3.5
Flag #1 & #2                          1 word     3.5 word-4.5
station ID  colatitude    12 bit    3/4 word     4.5 word-5.25
            longitude     12 bit    3/4 word     5.25word-6.0      -18byte
                                                         (CR-CR-LF)-21byte

__________________________________________________________________________

                          FREE SPACE 27 BYTES CODED
__________________________________________________________________________

D1 Indices and Baseline control     1/2 word     6.0 word-6.5
:
D18   "     "    "        "          1/2 word   15.5 word-15.0     -48byte
                                                        (CR-CR-LF)-51byte
__________________________________________________________________________

                          MINUTE VALUES 157 BYTES CODED
__________________________________________________________________________

C1 for t+0 minute                      1 word   15.0 word-16.0     -54byte
C2 for t+0 minute                      1 word   16.0 word-17.0     -57byte
C3 for t+0 minute                      1 word   17.0 word-18.0     -60byte
C4 for t+0 minute                      1 word   18.0 word-19.0     -63byte
:
C4 for t+4 minute                      1 word    34.0 word-35.0   -111byte
                                                        (CR-CR-LF)-114byte
C1 for t+5 minute                      1 word    35.0 word-36.0   -117byte
:
C4 for t+9 minute                      1 word    54.0 word-55.0   -174byte
                                                        (CR-CR-LF)-177byte
C1 for t+10 minute                     1 word    55.0 word-56.0   -180byte
:
C1 for t+11 minute                     1 word    59.0 word-60.0   -192byte
C2 for t+11 minute                     1 word    60.0 word-61.0   -195byte
C3 for t+11 minute                     1 word    61.0 word-62.0   -198byte
C4 for t+11 minute                     1 word    62.0 word-63.0   -201byte

CRC                                    1 word    63.0 word-64.0   -204byte
                                                    ('='-CR-CR-LF)-208byte
```

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.

```
min sec0....*....1....*....2....*....3....*....4....*....5....*....
12*(n) .....--M01================================================__
  +01  _____.....--M02=============================================
  +02  ===_______.....--M03========================================
  +03  ========_______.....--M04===================================
  +04  =============_______.....--M05==============================
  +05  ==================_______.....--M06=========================
  +06  =======================_______.....--M07====================
  +07  ============================_______.....--M08===============
  +08  =================================_______.....--M09==========
  +09  ======================================_______.....--M10=====
  +10  ===========================================_______.....--M11
  +11  ================================================____________
12(n+1).....--M01================================================__
  :
```

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:

```
 decimal  base-44     base-44
 number   number      char
      0   < 0, 0, 0>  000
      1   < 0, 0, 1>  001
     43   < 0, 0,43>  00?
     44   < 0, 1, 0>  010
  32767   <16,40,31>  G-V
     -1   <43,43,43>  ???
    -44   <43,43, 0>  ??0
  -1935   <43, 0, 1>  ?01
 -32768   <27, 3,12>  R3C
```

Table 1

DIGIT	BASE-44	DIGIT	BASE-44
< 0>	0	<22>	M
< 1>	1	<23>	N
< 2>	2	<24>	O
< 3>	3	<25>	P
< 4>	4	<26>	Q
< 5>	5	<27>	R
< 6>	6	<28>	S
< 7>	7	<29>	T
< 8>	8	<30>	U
< 9>	9	<31>	V
<10>	A	<32>	W
<11>	B	<33>	X
<12>	C	<34>	Y
<13>	D	<35>	Z
<14>	E	<36>	(
<15>	F	<37>	)
<16>	G	<38>	+
<17>	H	<39>	,(comma)
<18>	I	<40>	-(hyphen)

APPENDIX E-3

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 block header (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.
DDDDDDD	:	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.
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 tenths 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.

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_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.).
FFFFFFF	: Indicates Total Field data field.
_	: Indicates space character.
CrLf	: Indicates Carriage Return and Line Feed.

APPENDIX E-4

IBFV1.11 INTERMAGNET BASELINE FORMAT

This format is to be used to provide samples of baselines for use in examining equipment performance and for inclusion on the INTERMAGNET CD-ROM. 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_BBBBBBB_ZZZZZZZ CrLf.
   .        .          .          .       .
   .        .          .          .       .
   .        .          .          .       .
DDD_AAAAAAA_BBBBBBB_ZZZZZZZ CrLf.
*
001_AAAAAAA_BBBBBBB_ZZZZZZZ_FFFFF CrLf.
002_AAAAAAA_BBBBBBB_ZZZZZZZ_FFFFF CrLf.
003_AAAAAAA_BBBBBBB_ZZZZZZZ_FFFFF CrLf.
 .
 .
 .
366_AAAAAAA_BBBBBBB_ZZZZZZZ_FFFFF CrLf.
*
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
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 or X in 0.1 nT
BBBBBBB	:	Signed value of D or Y in 0.1 nT or 0.1 min of arc.
ZZZZZZZ	:	Signed value of Z 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 F-1

FILTER COEFFICIENTS FOR ONE MINUTE VALUES

Time in Seconds	Coef. for One Second Data	Coef. for Five Second Data	Coef. For Ten Second Data	Time in Seconds	Coef. for One Second Data	Coef. for Five Second Data	Coef. for Ten Second Data
t_0	0.02519580	0.12578865	0.25100743	t_{26}	0.00661811		
t_1	0.02514602			t_{27}	0.00595955		
t_2	0.02499727			t_{28}	0.00534535		
t_3	0.02475132			t_{28}	0.00477552		
t_4	0.02441104			t_{30}	0.00424959	0.02121585	0.04233562
t_5	0.02398040	0.11972085		t_{31}	0.0376666		
t_6	0.02346437			t_{32}	0.00332543		
t_7	0.02286881			t_{33}	0.0029243		
t_8	0.02220039			t_{34}	0.00256140		
t_9	0.02146643			t_{35}	0.00223468	0.01115655	
t_{10}	0.02067480	0.10321785	0.20596804	t_{36}	0.00194194		
t_{11}	0.01983377			t_{37}	0.00168089		
t_{12}	0.01895183			t_{38}	0.00144918		
t_{13}	0.01803763			t_{39}	0.00124449		
t_{14}	0.01709976			t_{40}	0.00106449	0.00531440	0.01060471
t_{15}	0.01614667	0.08061140		t_{41}	0.00090693		
t_{16}	0.01518651			t_{42}	0.00076964		
t_{17}	0.01422707			t_{43}	0.00065055		
t_{18}	0.01327563			t_{44}	0.00054772		
t_{19}	0.01233892			t_{45}	0.00045933	0.00229315	
t_{20}	0.01142303	0.05702885	0.11379931	t_{46}			
t_{21}	0.01053338			t_{47}			
t_{22}	0.00967467			t_{48}			
t_{23}	0.00885090			t_{49}			
t_{24}	0.00806530			t_{50}			0.00178860
t_{25}	0.00732042	0.03654680					

APPENDIX G-1

INTERMAGNET MEMBERSHIP APPLICATION (V-2.1 Dec. 99)

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

Dr. A. W. Green, Secretary
INTERMAGNET Executive Council
c/o U. S. Geological Survey
Box 25046 MS 968
Denver, CO 80225-0046
USA

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.

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:

Laszlo Hegymegi
Eotvos Lorand Geophysical Institute of Hungary
Budapest XIV., Columbus u. 17-23
Budapest 70, P.O.B. 35
H-1440
HUNGARY
TEL: 36-1-384-3302
FAX: 36-1-384-3306
INTERNET: hegymegi@elgi.hu

DOCUMENTS AVAILABLE

INTERMAGNET Technical Reference Manual.
INTERMAGNET Membership Application
Suppliers of Observatory and Data Transmission Equipment.

Write to: Edward A. Sauter, Secretary
INTERMAGNET Operations Committee
c/o U.S. Geological Survey
Box 25046 MS 968
Denver Federal Center
Denver, Colorado
80225-0046
USA

APPENDIX G-1 (Cont'd)

INTERMAGNET MEMBERSHIP APPLICATION FORM (V-2.1 Dec. 99)

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-2.1 Dec. 99)

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 gives 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:	Filtered		Standard		Optional	
	Yes	No	Yes	No	Yes	No
1min	( )	( )	( )	( )	( )	( )
5sec	( )	( )	( )	( )	( )	( )
1sec	( )	( )	( )	( )	( )	( )
Other_____	( )	( )	( )	( )	( )	( )

Data storage capacity: _____________Weeks

Uninterruptible power supply: Yes ( ) No ( )

If backup capability: _____________Hours

D. DATA TRANSMISSION

An IMO must communicate its data to a GIN within 72 hours either by Satellite or E-mail.

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 ( ) Hiraiso ( ) 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; for example, as baseline graphs showing observed and adopted baseline values. Please give details on the baseline adoption procedure and explain offsets if there are any.

Expected baseline variation [5nT/year]: ________________nT/year

APPENDIX G-1 (Cont'd)

F. ABSOLUTE INSTRUMENTS

1. Declination (D)

Instrument Type: ______________________________
Manufacturer: ______________________________
Measurement accuracy: _______________
Measurement frequency: _______________

2. Inclination (I)

Instrument Type: ______________________________
Manufacturer: ______________________________
Measurement accuracy: _______________
Measurement frequency: _______________

3. Total field (F)

Instrument Type: ______________________________
Manufacturer: ______________________________
Measurement accuracy: _______________
Measurement frequency: _______________

4. Horizontal component (H)

Instrument Type: ______________________________
Manufacturer: ______________________________
Measurement accuracy: _______________
Measurement frequency: _______________

5. Vertical component (Z)

Instrument Type: ______________________________
Manufacturer: ______________________________
Measurement accuracy: _______________
Measurement frequency: _______________

Acknowledgments

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

EXCON	OPSCOM
William F. Stuart UK	Lanny Wilson USA
	Doug F. Trigg Canada
	Francois-Xavier Lalanne France
	Gerrit Jansen van Beek Canada

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