Cluster Science Archive:

Interface Control Document for FGM

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DOCUMENT STATUS SHEET

Issue	Date	Details
Version 1 Draft 01	07.12.2004	
Version 1 Draft 02	22.04.2005	
Version 1 Draft 03	22.04.2005	
Version 1 Draft 04	29.05.2005	
Version 2 Draft 01	18.06.2005	
Version 2 Draft 02	09.11.2006	
Version 2 Draft 03	27.02.2008	
Version 2 Draft 04	07.05.2008	
Version 3	29.04.2010	
Version 4	10.05.2012	
Version 5	10.05.13	
Version 6	15.05.14	
Version 6 Revision 1	30.10.15	
Version 6 Revision 2	18.12.15	
Version 7	18.05.2025	Updates in preparation for post-operations review

DOCUMENT CHANGE RECORD

Issue	RID/Ref	Details
7	Table of Contents	Updated for new sub-sections
7	Section 2	Updated Point of Contact details
	3	Added Extended Mode (Section 3.5.4)
7	4	Added EXTM (Section 4.3.4 and 4.4.1)
7	5	Added DOI numbers (Sections 5.1-5.11)
7	5	Added Extended Mode metadata (Section 5.4)
7	All sections	Updated from CAA to CSA, minor grammatical corrections and clarifications

TABLE OF CONTENTS

1 PURPOSE

The purpose of this document is to provide a broad outline of the archiving of the data from the FGM instrument on Cluster in the ESA Cluster Science Archive (CSA, formerly CAA), and to define the agreement of the CSA and PI of FGM on this broad outline.

The scientific rationale underpinning the CSA activities is as follows:

- Maximise the scientific return from the mission by making all Cluster data available to the worldwide scientific community
- Ensure that the unique data set returned by the Cluster mission is preserved in a stable, long-term archive for scientific analysis beyond the end of the mission
- Provide this archive as a major contribution by ESA and the Cluster science community to the International Living With a Star programme

In the case of FGM the main responsibilities will be:

- Provision of full pre-processed FGM data set suitable for science studies, at highest time resolution and appropriate time averages
- Provision of raw data together with processing software and a set of calibration files in order to generate processed data to a specified precision on each component
- Provision of software to generate FGM data in the FS (spinning, sensor) co-ordinate system in nT without calibration applied

The FGM team will be responsible for the provision of the following deliverables to the CSA:

- Magnetic field data at full resolution of the instrument specified in Section 5.1 of the document
- Magnetic field data at 5 vectors/second specified in Section 5.2 of this document
- Magnetic field data at spin resolution specified in Section 5.3 of this document
- Extended Mode data at spin resolution specified in Section 5.4 of this document
- Data processing software specified in Section 5.5 of this document
- Calibration files specified in Section 5.6 of this document
- Auxiliary data files specified in Sections 5.7, 5.8, 5.9, 5.10 and 5.11 of this document
- Documentation specified in Section 5.12 of this document

2 POINTS OF CONTACT

For the operation of archiving the high-resolution data from FGM the following contacts have been agreed:

- as scientific correspondents, Philippe Escoubet for the CSA and <CAA_INST_SCI> Chris Carr for FGM,
- as technical correspondents, Chris Perry for the CSA and <CAA_INST_TM> Leah-Nani Alconcel for FGM,
- as managerial correspondents, Philippe Escoubet for the CSA and Chris Carr for FGM.

3 INSTRUMENT DESCRIPTION

3.1 Science Objectives

The objective of the FGM investigation is the accurate determination of the magnetic field vector (DC to 10 Hz) at the location of the four Cluster spacecraft, with high time resolution, to provide observations for the study of:

- small scale 3D plasma processes in the different regions of the magnetosphere and in the near-Earth interplanetary space
- the 3D structure and dynamics of magnetospheric boundaries

3.2 Hardware Overview

Each Cluster spacecraft carries an identical FGM instrument (Fluxgate Magnetometer) to measure the magnetic field [Balogh et al., 1997, 2001]. Each instrument, in turn, consists of two triaxial fluxgate magnetometers and an onboard data processing unit. The magnetometers are similar to many previous instruments flown in Earth-orbit and on other, planetary and interplanetary missions. In order to minimise the magnetic background of the spacecraft, one of the magnetometer sensors (the outboard, or OB sensor) is located at the end of one of the two 5.2 m radial booms of the spacecraft, the other (the inboard, or IB sensor) at 1.5 m inboard from the end of the boom. In flight, either sensor can be designed as the Primary Sensor, for acquiring the main data stream of the magnetic field vectors. In the default configuration, the OB sensor is used as the Primary Sensor. The instrument is designed to be highly failure-tolerant through a full redundancy of all its functions. The magnetometers can measure the three components of the field in six ranges, as shown in Table 1.

Switching between ranges is either automatic, controlled by the instrument Data Processing Unit (DPU) in flight, or set by ground command. When in the automatic mode, a range selection algorithm running in the DPU continuously monitors each component of the measured field vector. If any component exceeds a fraction (set at 90%) of the range, an up-range command is generated and transmitted to the sensor at the start of a new telemetry format. (All three components are measured in the same range.) If all three components are smaller than 12.5% of the range for more than a complete spin period (implemented as more than a telemetry reset period, or 5.15222 s), a downrange command is implemented at the start of the next telemetry format. The facility to override the automatic ranging is included partly for test purposes, partly as a capability for failure recovery.

RANGE NUMBER	RANGE	RESOLUTION
2	- 64 nT to + 63.97 nT	$7.8\mathrm{x}10^{-3}$ nT
3	- 256 nT to + 255.87 nT	$3.1\mathrm{x}10^{-3}$ nT
4	- 1,024 nT to + 1,023.5 nT	0.125 nT
5	- 4,096 nT to + 4,094 nT	0.5 nT
6	- 16,385 to + 16,376 nT	2 nT
7	-65,536 to + 65,536 nT	8 nT

Table 1: FGM Operating Ranges and Resolution

The sampling of vectors from the magnetometer sensor designated as the primary sensor is carried out at the rate of 201.75 vectors/second. The full bandwidth of the sampled vectors cannot be routinely transmitted via the telemetry because of the limited telemetry rate allocation. The Central Processor Unit convolves the full bandwidth data with a Gaussian digital filter to match the rate and bandwidth of the transmitted vectors to the available telemetry rate. The filter coefficients are selected from stored sets corresponding to the different telemetry modes.

FGM full-resolution data consist of time series of magnetic field vectors for each of the four spacecraft, with the time resolution defined by the spacecraft telemetry mode and the FGM telemetry. The most frequently used FGM telemetry modes are indicated in bold in Table 2.

Spacecraft TM modes	FGM telemetry modes	Vector/s (primary sensor)	Vectors/s (secondary sensor)
Nominal Modes 1, 2, 3 and Burst Mode 2	A	15.519	1.091
	B	18.341	6.957
	C	**22.416**	**3.011**
Burst Mode 1	**D**	**67.249**	**7.759**
Burst Mode 3	F	(MSA dump)	

TABLE 2: FGM vector rates

3.3 Instrument calibration

Calibration in this context represents the determination of parameters that allow the transformation of raw measurements transmitted through the telemetry into a magnetic field vector, given in physical units (nT), in an instrument-specific coordinate system that is unambiguously related to the coordinate system of the spacecraft. The calibration parameters are used by the data processing software (see Section 3.4) to generate the magnetometer data in a range of geophysical coordinate systems. The determination of the offsets and gains for ranges 6 and 7 are dependent on the range 5 calibrated data.

The in-flight calibration of FGM is based on an evaluation of all the possible sources of errors that occur in the measurement process, embodied in an “instrument model” representing the measurement process of the magnetic field. Conceptually, the actual value of the ambient magnetic field vector at the location of the FGM sensor (given, for instance, in Geocentric Solar-Ecliptic, *GSE*, coordinates, as $\mathbf{B}_{GSE}$), is measured by the FGM output through the telemetry as a digitised vector **V**. This vector (the actual measurement) depends in a complex, but linear way on the alignment and orthogonality of the sensor axes with respect to the *GSE* coordinate system; on the scale factors and offsets of the sensors and electronics of FGM;

and on the offsets introduced by the spacecraft. The instrument model also needs to take into account the time and frequency response in the form of delays and effective bandwidth due to the magnetometers, the Analogue-to-Digital Converters, and the digital filtering process. The coordinate transformation from GSE into the (nearly, but not quite orthogonal) magnetometer sensor system (specific to each of the eight magnetometers on the four Cluster spacecraft) is a complex superposition of transformations that take into account also the misalignments introduced by the spacecraft, the magnetometer booms, sensor mounting and construction. All these effects need, in principle, to be evaluated for each of the measured output vectors.

All technical details of the FGM calibration processes are presented in the calibration report.

3.4 Data Processing Chain

The data processing software routinely applied to the FGM data has the following main tasks:

- Transformation of the raw telemetry data into a format suitable for further processing;
- Reconstruction of the time at which the vector data were measured;
- Application of the calibration parameters to correct instrumental and other effects in the data to recover the accurate value of the magnetic field at the location of the sensors;
- Despinning and transformation of the magnetic field vectors into standard geophysical coordinate systems.

The data processing also performs the following additional tasks:

- Merging of the spacecraft position vectors to the magnetometer data streams; these are based on the reconstituted orbit files delivered in the RDM files
- Averaging the measured magnetic field vectors over different time intervals;
- Providing appropriate data interfaces for the generation of standard FGM data products.

The basic input to the processing suit comes from either the Cluster Data Disposition System (CDDS) at ESOC, representing quick-look data, or from the Cluster Raw Data Medium (CRDM), the CDROMs used for the distribution of Cluster data. The different modules of the FGM data processing software implement the transformations enumerated and described above.

The module fgmtel.c unpacks the telemetry and generates vectors in physical units in the (unorthogonalised) sensor coordinate system. This module also generates the timing and spin phase information for each measured vector.

The module fgmcal.c incorporates the calibration files, determined outside the processing chain, and generates the orthogonalised vectors in the spin-aligned coordinate system.

The following software module, fgmhrt.c, despins the vectors, and, using the spacecraft attitude data, outputs a time series $\mathbf{B}_{GSE}$ in a selected geophysical system, normally in *GSE*, at the highest resolution in the current mode of the instrument, according to

$$\mathbf{B}_{GSE} = \underline{\underline{c}}^{(att)^{-1}} \underline{\underline{c}}^{(spin)^{-1}} \mathbf{B}_{FSR}$$

using the notation from Section 3.3. Additional features (processing of the spacecraft position and averaging, using the fgmav.c module) are used as appropriate.

3.5 Instrument Data Products

3.5.1 FGM full resolution data

FGM full-resolution data to be submitted to the CSA will consist of processed, calibrated and validated time series for the four spacecraft, with the time resolution defined by the spacecraft telemetry mode and the FGM telemetry mode from the FGM Primary sensor alone. The most used FGM telemetry modes are indicated in bold in Table 2.

The data submitted to the CSA are processed by the highest quality calibration files available at the time of the submission of the data. At the date of the submission, headers attached to the data will describe the details of the status of calibration and validation, and will also identify the calibration files used to generate the processed data. Each processed data block (to consist of a number of files of different data types and ancillary files), for a given time interval (hours, days, or months) submitted to the CSA will be fully identified in the associated documentation to allow its substitution if, for whatever reason, a higher quality data set becomes available later during the active phase of the CSA.

FGM data files submitted to the CAA contain the following parameters:

- Time (ISO time)
- Half interval of time over which magnetic field is averaged, in s
- Magnetic field vector GSE(X) component in nT
- Magnetic field vector GSE(Y) component in nT
- Magnetic field vector GSE(Z) component in nT
- Magnetic field vector magnitude in nT
- Position vector GSE(X) component in km
- Position vector GSE(Y) component in km
- Position vector GSE(Z) component in km
- FGM range (unitless: 2,3,4,5,6 or 7 corresponding to the ranges used in flight)
- FGM Telemetry Mode (unitless: 15, 18, **22** or **67** corresponding to the modes in Table 2)

The identification of the spacecraft and time period covered is included in the file header (see Section 5).

3.5.2 FGM 5 vectors/second data and software

An additional, uniformly 5 vectors/second high-resolution data set is also produced. This is independently processed (i.e. not simply the averaged full-resolution data), using the same calibration files as used for the full-resolution data set. The content of the data files will have an identical format to the full-resolution data set. The objective of submitting this data set to the CAA is that, from experience, it is expected to be the most generally usable sub-spin resolution data for scientific studies.

3.5.3 FGM spin-resolution data

This is an independently generated spin-resolution data set, processed from the raw data and using the same calibration files that are used to generate the two higher-resolution data sets. The content of the data files will have an identical format to the full-resolution data set. This is different from the FGM Prime Parameter Data Set (PP) which does not contain the spacecraft position data or additional range and telemetry mode information. The spin phasing of this data set is 26.367 degrees, the same as used to generate PP data.

The validated FGM Prime Parameter Data Set that has been generated throughout the mission by the CSDS is archived in the CSA as a component of the CSDS data collection.

3.5.4 FGM Extended Mode data

For periods in the mission where instrument operations were not scheduled (particularly 2001-2002, where the nominal mission only covered about 50% of each orbit) the FGM instruments were often commanded into an 'extended mode' whereby *estimates* of the spin-averaged magnetic field vector were calculated and stored in FGM internal memory, then subsequently downlinked at a later date. Consequently, gaps in the primary data-products of up to 23 hours are bridged by this supplementary dataset, which must be understood to be of significantly lower quality and precision, both in terms of calibrated accuracy and timing. The process and product are further described in the FGM User Guide [CAA-EST-UG-FGM]. The presentation and formatting of the Extended Mode data is very similar to the spin-resolution dataset [3.5.3].

3.5.5 Data Processing Software

It is expected that most users of the CSA will be accessing one of the FGM processed data sets described in the previous sections. In principle on demand processing could be made available but there is no need for it at the moment.

3.5.6 Calibration Files

FGM calibration files consist of text files for a given period of validity, one file per orbit for each spacecraft. The files contain numerical values for the 3 x 3 matrix $\underline{\underline{c}}^{cal}$ and the offset vector $\mathbf{o}^{cal}$ for FGM ranges 2, 3, 4, 5, 6 and 7, for both inboard and outboard sensors, and for both A-D converters. However, it is anticipated that only those parameters required to generate data during the interval of calibration file validity will be included in the file in the first instance. The calibration filename contains information on the period of validity of the data within the file.

In addition the calibration parameters will be included in the calibration files. These parameters reflect the calibration process from which the 3 x 3 matrix $\underline{\underline{c}}^{cal}$ and the offset vector $\mathbf{o}^{cal}$ are derived as used by the FGM Data Processing software.

3.5.7 Auxiliary data

Additional auxiliary data products will be supplied:

- A static experiment caveat file
- Instrument caveat files
- Data gap files, listing intervals of missing data after processing but before validation
- Files listing additional intervals of missing data introduced by the validation procedure

4 DATA PROVISION – GENERAL CONVENTIONS

4.1 Formats

Pre-generated data products are in Cluster Exchange Format (CEF-2) as defined in reference document DS-QMW-TN-0010, [QMW-CDF].

The output of the data processing software are also in CEF-2 format, with the same metadata entries as the pre-generated products.

The three different time resolution magnetic field data products all have the same data format, the contents of which are described in this section.

All documentation is submitted as PDF files.

4.2 Standards

Metadata definitions comply with CEF-2 metadata dictionary defined in the document CAA-MDD-0001 v.3.6.

4.3 Production Procedures

Pre-generated data products stored in the CSA will be produced at Imperial College by the FGM team.

4.3.1 Summary of calibration process

- The calibration of FGM data involves the analysis of 22 (NM mode) or 67 (BM mode) vectors/second data in order to estimate the 12 fundamental calibration parameters for each instrument range. There are 6 angles which relate the actual orientation of the sensor to the nominal orientation of the sensor on the boom. There are also 3 sensor gains and 3 sensor offsets.
- 8 of the fundamental parameters for each instrument range can be estimated from Fourier analysis techniques devised by Kepko et al.
- A number of other techniques can then be used to gain information about the remaining calibration parameters.
- The calibration analysis is ideally performed orbit by orbit from perigee to perigee, although due to data coverage and the limitations of some of the methods, longer periods may be considered for the calculation of some of the parameters.
- The offset in the spin-axis field that is seen in Cluster 1 when the HPA (High Powered Amplifier) is switched between High Power, Low Power and Off is corrected for.
- Calibration files have a validity which typically covers the period of an orbit from perigee to perigee. In order to assess the success of the calibration of a particular orbit of data, spectrograms are produced using full resolution calibrated data. These spectrograms are used to quantify the level of residual spin tone remaining in the spin axis and spin plane data after calibration.
- If the remaining spin tone is above an acceptable limit after the calibration analysis has been performed then a caveat file is created for that particular orbit. This situation can occur during the eclipse seasons when calibration parameters are changing on short timescales. Signal to noise ratio thresholds for all 6 ranges for the dayside and tail season have been calculated so that high spin tone can be automatically identified.

4.3.2 Calibration file format

The calibration files can be used either to generate data at full resolution, or averaged data, in a range of co-ordinate systems. Each calibration file has two sections. The first lists the 3 components of the FGM offset along with the 9 elements of the calibration matrix which can be used to transform magnetic field data from the near orthogonal sensor triad (FS) into an orthogonal spacecraft co-ordinate system (FSR). The transformation equation is shown in calibration report. The offsets referred to here are orthogonalised offsets, which means they are the sensor offsets which have been multiplied by the calibration matrix. This transformation brings the sensor offsets into the FSR coordinate system. The transformation matrix depends on the range in which the instrument is operating, when ranges 2 through 7 are calibrated there are six sets of elements, one for each of the six instrument ranges. There are also different elements for different FGM ADCs and sensors.

This part of the file starts with a header line, followed by a table of 6 columns and 48 rows. The first 5 columns refer to the instrument ranges and the last column is a code which gives information about which ADC and sensor the parameters refer to. The first 3 rows of the table correspond to the three orthogonalised offsets for the first ADC/sensor combination. The next eight elements correspond to the calibration matrix for the same ADC/sensor combination. The matrix element being referred to in each row is given in the last two numbers in the code in column 6. An annotated example calibration file is shown below and explains how the different calibration matrix components are put together into the 3X3 calibration matrix used to calibrate the data as described in section 3.3. The following rows in this table then follow the same format for each of the ADC/sensor combinations. The different ADC/sensor combinations are given by the first two characters of the codes in column 6. The characters cover the set of values S1 to S4 and the different ADC/sensor combinations these refer to are given in the first line of the footer of each file which is underneath the main table of calibration elements. Since each calibration file is typically generated from data from a single orbit, and the instrument might not necessarily operate in every range during every orbit, matrix elements are only given for those ranges which were used during the time defined by the interval of validity of the calibration file, which is specified as two dates in the calibration file name for pre 2009 data files. In the newer format data files (post 2009 data and earlier data reprocessed since then) calibration parameters are present for all 6 ranges. If there is no data for that range in the given orbit then calibration parameters from a previous well calibrated orbit are placed in the file.

Two example calibration files with annotation in blue are given below. The first file shows calibration files from November 2009 onwards which include calibration of ranges 6 and 7. The second file type was used prior to this when these higher ranges were rarely observed so there is no calibration for higher range data.

Data file with Range 6 and 7 calibration

- Calibration files from November 2009 onwards which include calibration of ranges 6 and 7 and earlier data that has been reprocessed.

The transformation matrix depends on the range in which the instrument is operating, so there are six sets of elements, one for each of the six instrument ranges (2, 3, 4, 5, 6 and 7). The first 5 columns refer to the instrument ranges 2, 3, 4, 5 and 6. The orthogonalized calibration matrix for Range 7 data is given below the estimated parameters.

Three components of offset

Range 2 calibration	Range 3 calibration	Range 4 calibration	Range 5 calibration	Range 6 calibration	
-0.0265101	0.0911731	2.8563561	3.9561477	36.3286008	S1_01
-2.6979479	-2.6031780	-2.4177004	-2.0516050	-8.8321852	S1_02
-0.9267399	-0.9888635	-0.4956407	0.0853318	1.0661880	S1_03
1.0430317	1.0244978	1.0142609	0.9967147	1.0152606	S1_11
-0.0029720	-0.0031228	-0.0029773	-0.0029557	-0.0029314	S1_12
0.0066191	0.0058980	0.0059042	0.0058135	0.0057470	S1_13
-0.0089631	-0.0085329	-0.0089937	-0.0091391	-0.0094794	S1_21
1.0496484	1.0316773	1.0189060	1.0023886	1.0210311	S1_22
-0.0000569	-0.0001334	0.0018850	0.0017003	0.0010174	S1_23
-0.0063159	-0.0045357	-0.0025962	-0.0021632	-0.0010331	S1_31
-0.0114820	-0.0112990	-0.0131456	-0.0125973	-0.0122468	S1_32
1.0572026	1.0390855	1.0148212	0.9996554	1.0160099	S1_33
-2.8135333	-2.7121578	-32.7831614	-30.0284767	0.0000000	S2_01
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	S2_02
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	S2_03
1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	S2_11
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	S2_12
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	S2_13
-0.0000000	-0.0000000	-0.0000000	-0.0000000	-0.0000000	S2_21
1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	S2_22
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	S2_23
-0.0000000	-0.0000000	-0.0000000	-0.0000000	-0.0000000	S2_31
-0.0000000	-0.0000000	-0.0000000	-0.0000000	-0.0000000	S2_32
1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	S2_33
-2.8135333	-2.7121578	-32.7831614	-30.0284767	0.0000000	S3_01
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	S3_02
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	S3_03
1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	S3_11
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	S3_12
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	S3_13
-0.0000000	-0.0000000	-0.0000000	-0.0000000	-0.0000000	S3_21
1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	S3_22
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	S3_23
-0.0000000	-0.0000000	-0.0000000	-0.0000000	-0.0000000	S3_31
-0.0000000	-0.0000000	-0.0000000	-0.0000000	-0.0000000	S3_32
1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	S3_33
-2.8135333	-2.7121578	-32.7831614	-30.0284767	0.0000000	S4_01
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	S4_02
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	S4_03
1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	S4_11
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	S4_12
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	S4_13
-0.0000000	-0.0000000	-0.0000000	-0.0000000	-0.0000000	S4_21
1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	S4_22
0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	S4_23
-0.0000000	-0.0000000	-0.0000000	-0.0000000	-0.0000000	S4_31
-0.0000000	-0.0000000	-0.0000000	-0.0000000	-0.0000000	S4_32
1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	S4_33

```
S1 - OB + ADC1, S2 = IB + ADC1, S3 = OB + ADC2, S4 = IB + ADC2
ranges = 2,3,4,5,7 => 64, 256, 1024, 4096, 65000 nT
Calibrated for time range 20-Feb-2010 06:45:24 - 22-Feb-2010 13:01:31.
Calibrated for spacecraft 2 (Salsa).
Created by FGMCal on 25-Mar-2011.
Contact Leah-Nani Alconcel (l.alconcel@imperial.ac.uk) for details.

Estimated parameters:
Sensor 1 (outboard), ADC 1, range 2
Components  :         X,        Y,        Z
Offsets (nT):    -0.027,   -2.571,   -0.905
Gains       :  +0.95875, +0.95276, +0.94593
Theta (deg) :    +0.392,  +89.508,  +89.648
Phi (deg)   :   -66.188,   +0.000,  +89.372

Sensor 1 (outboard), ADC 1, range 3
Components  :         X,        Y,        Z
Offsets (nT):    +0.087,   -2.523,   -0.979
Gains       :  +0.97611, +0.96935, +0.96243
```

```
Theta (deg) :     +0.367,   +89.523,   +89.741
Phi (deg)   :    -62.420,    +0.005,   +89.372

Sensor 1 (outboard), ADC 1, range 4
Components  :          X,         Y,         Z
Offsets (nT):     +2.812,    -2.347,    -0.512
Gains       :   +0.98597,  +0.98149,  +0.98544
Theta (deg) :     +0.371,   +89.492,   +89.847
Phi (deg)   :    -63.947,    -0.109,   +89.260

Sensor 1 (outboard), ADC 1, range 5
Components  :          X,         Y,         Z
Offsets (nT):     +3.963,    -2.011,    +0.069
Gains       :   +1.00333,  +0.99767,  +1.00039
Theta (deg) :     +0.372,   +89.475,   +89.869
Phi (deg)   :    -63.709,    -0.101,   +89.280

Sensor 1 (outboard), ADC 1, range 6
Components  :          X,         Y,         Z
Offsets (nT):    +35.753,    -8.319,    +0.985
Gains       :   +0.98501,  +0.97946,  +0.98430
Theta (deg) :     +0.362,   +89.465,   +89.935
Phi (deg)   :    -63.650,    -0.060,   +89.313

Sensor 1 (outboard), ADC 1, range 7
Components  :          X,         Y,         Z
Offsets (nT):    +50.982,    -4.885,    +7.050
Gains       :   +1.00288,  +0.99600,  +1.00001
Theta (deg) :     +0.360,   +89.438,   +89.911
Phi (deg)   :    -63.672,    -0.082,   +89.290

#!Range7
     50.8914937     -5.3941204      7.0384961
      0.9971722     -0.0028706      0.0056328
     -0.0097802      1.0040798      0.0013834
     -0.0014271     -0.0124388      1.0000418

File ends.
```

Data file type used for datasets prior November 2009

The transformation matrix depends on the range in which the instrument is operating, so there are five sets of elements, one for each of the five instrument ranges (2, 3, 4, 5 and 7). The first 5 columns refer to the instrument ranges 2, 3, 4, 5 and 7. Range 7 was only included in this cal file due to its occasional use during instrument operation on the ground prior to launch.

	Range 2 calibration	Range 3 calibration	Range 4 calibration	Range 5 calibration	Range 7 calibration	
	T24:00:00.000					
Three components of offset	-2.7886408	-2.7190993	-32.7906833	0.0000000	0.0000000	S1_01
	4.4201562	4.4851886	15.6573872	0.0000000	0.0000000	S1_02
	0.8501683	0.9441388	-1.5077695	0.0000000	0.0000000	S1_03
1st row of calibration matrix	1.0525503	1.0339678	1.0215289	1.0000000	1.0000000	S1_11
	0.0068837	0.0070519	0.0068510	0.0000000	0.0000000	S1_12
	0.0120698	0.0119024	0.0114334	0.0000000	0.0000000	S1_13
2nd row of calibration matrix	0.0040290	0.0038570	0.0038590	-0.0000000	-0.0000000	S1_21
	1.0522141	1.0336735	1.0156631	1.0000000	1.0000000	S1_22
	0.0000462	0.0000444	0.0000432	0.0000000	0.0000000	S1_23
3rd row of calibration matrix	0.0067935	0.0064793	0.0063575	-0.0000000	-0.0000000	S1_31
	-0.0079233	-0.0082804	-0.0095574	-0.0000000	-0.0000000	S1_32
	1.0364527	1.0178109	1.0047788	1.0000000	1.0000000	S1_33
	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	S2_01
	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	S2_02
	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	S2_03
	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000	S2_11
	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	S2_12
	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	S2_13

```
    -0.0000000    -0.0000000    -0.0000000    -0.0000000    -0.0000000   S2_21
     1.0000000     1.0000000     1.0000000     1.0000000     1.0000000   S2_22
     0.0000000     0.0000000     0.0000000     0.0000000     0.0000000   S2_23
    -0.0000000    -0.0000000    -0.0000000    -0.0000000    -0.0000000   S2_31
    -0.0000000    -0.0000000    -0.0000000    -0.0000000    -0.0000000   S2_32
     1.0000000     1.0000000     1.0000000     1.0000000     1.0000000   S2_33
     0.0000000     0.0000000     0.0000000     0.0000000     0.0000000   S3_01
     0.0000000     0.0000000     0.0000000     0.0000000     0.0000000   S3_02
     0.0000000     0.0000000     0.0000000     0.0000000     0.0000000   S3_03
     1.0000000     1.0000000     1.0000000     1.0000000     1.0000000   S3_11
     0.0000000     0.0000000     0.0000000     0.0000000     0.0000000   S3_12
     0.0000000     0.0000000     0.0000000     0.0000000     0.0000000   S3_13
    -0.0000000    -0.0000000    -0.0000000    -0.0000000    -0.0000000   S3_21
     1.0000000     1.0000000     1.0000000     1.0000000     1.0000000   S3_22
     0.0000000     0.0000000     0.0000000     0.0000000     0.0000000   S3_23
    -0.0000000    -0.0000000    -0.0000000    -0.0000000    -0.0000000   S3_31
    -0.0000000    -0.0000000    -0.0000000    -0.0000000    -0.0000000   S3_32
     1.0000000     1.0000000     1.0000000     1.0000000     1.0000000   S3_33
     0.0000000     0.0000000     0.0000000     0.0000000     0.0000000   S4_01
     0.0000000     0.0000000     0.0000000     0.0000000     0.0000000   S4_02
     0.0000000     0.0000000     0.0000000     0.0000000     0.0000000   S4_03
     1.0000000     1.0000000     1.0000000     1.0000000     1.0000000   S4_11
     0.0000000     0.0000000     0.0000000     0.0000000     0.0000000   S4_12
     0.0000000     0.0000000     0.0000000     0.0000000     0.0000000   S4_13
    -0.0000000    -0.0000000    -0.0000000    -0.0000000    -0.0000000   S4_21
     1.0000000     1.0000000     1.0000000     1.0000000     1.0000000   S4_22
     0.0000000     0.0000000     0.0000000     0.0000000     0.0000000   S4_23
    -0.0000000    -0.0000000    -0.0000000    -0.0000000    -0.0000000   S4_31
    -0.0000000    -0.0000000    -0.0000000    -0.0000000    -0.0000000   S4_32
     1.0000000     1.0000000     1.0000000     1.0000000     1.0000000   S4_33

S1 - OB + ADC1, S2 = IB + ADC1, S3 = OB + ADC2, S4 = IB + ADC2
ranges = 2,3,4,5,7 => 64, 256, 1024, 4096, 65000 nT
Calibrated for time range Calibrated for spacecraft 1 (Rumba).
Created by FGMCal on 12-Mar-2005.
Contact Leah-Nani Alconcel (l.alconcel@imperial.ac.uk) for details.

Estimated parameters:
Sensor 1 (outboard), ADC 1, range 2
Components   :         X,         Y,         Z
Offsets (nT):     -2.687,    +4.211,    +0.870
Gains        :   +0.95025, +0.95041, +0.96495
Theta (deg)  :     +0.768,   +90.219,   +90.371
Phi (deg)    :   -119.654,    +0.000,   +89.566

Sensor 1 (outboard), ADC 1, range 3
Components   :         X,         Y,         Z
Offsets (nT):     -2.671,    +4.349,    +0.980
Gains        :   +0.96733, +0.96745, +0.98262
Theta (deg)  :     +0.778,   +90.214,   +90.361
Phi (deg)    :   -120.600,    +0.000,   +89.539

Sensor 1 (outboard), ADC 1, range 4
Components   :         X,         Y,         Z
Offsets (nT):    -32.191,   +15.538,    -1.149
Gains        :   +0.97911, +0.98461, +0.99538
Theta (deg)  :     +0.761,   +90.216,   +90.359
Phi (deg)    :   -121.057,    +0.000,   +89.458

File ends.
```

FGM calibration files have the following naming convention:
Cx_CC_FGM_CALF__yyyymmdd_hhmmss_yyyymmdd_hhmmss_Vxx.fgmcal
The files are in ascii format, but are not compliant with CEF-2. The part of the file containing the matrix elements is read by the FGM data processing software in order to generate magnetic

field data products. Transformation of the data from the spacecraft co-ordinate system (FSR) into other systems, such as GSE, can be done through the data processing software.

The second half of the file consists of free text defining the numerical values of the physical offsets, gains, and angles for each sensor in each of the ranges used during that interval of data.

4.3.3 Production of CEF-2 format data products

The standard FGM data processing software is used to unpack the raw data, calibrate the data, average the data and transform the data into GSE coordinates. A new pipeline program called caavec.c has been written to take template CEF-2 header files for each data product and fill the sections which are specific to a particular file. The mission level and observatory level metadata are incorporated using the CSA provided include files CL_CQ_MISSION.ceh and Cx_CQ_OBS.ceh. The experiment level metadata are incorporated using an experiment level include file CL_CH_FGM_EXP.ceh, which is a deliverable to the CSA.

The caavec.c program then appends the data to the end of the headers in the correct CEF-2 format. A perl script is used as a wrapper around the data processing chain to control the periods of data to be processed and the data products produced.

4.3.4 Magnetic field data file format

Each calibration file will be used to generate three data sets of magnetic field data for each spacecraft, where x indicates the spacecraft number in the following data set ID list:

Cx_CP_FGM_FULL : Magnetic field data at full resolution.
Cx_CP_FGM_5VPS : Magnetic field data averaged to 5 vectors/second.
Cx_CP_FGM_SPIN : Magnetic field data averaged over one complete spin, starting at a spin phase of 26.367degrees.

Each file from each of these datasets contains an equivalent set of parameters and thus the same format. The parameters are listed here for the full resolution data product:

Time__C1_CP_FGM_FULL : Time (ISO_TIME)
half_interval__C1_CP_FGM_FULL : Half interval over which magnetic field is averaged (Units: s)
B_vec_xyz_gse__C1_CP_FGM_FULL : Magnetic field vector (3 components: GSE; Units: nT)
B_mag__C1_CP_FGM_FULL : Magnetic field magnitude (Units: nT)
sc_pos_xyz_gse__C1_CP_FGM_FULL : Spacecraft position (3 components: GSE; Units: km)
range__C1_CP_FGM_FULL : Instrument range (integer)
tm__ C1_CP_FGM_FULL : Telemetry mode (number of vectors/second in full resolution data stream rounded to an integer).

tm__C1_CP_FGM_FULL can take the following values: 15, 18, 22, and 67 which correspond to telemetry modes A, B, C, and D respectively, described in Section 3.2, Table 2. An equivalent parameter, containing the number of vectors/second in the full data stream, is included in all magnetic field data files, not just the full resolution data files.

The data files for C2, 3 and 4 have similar variable names with C1 replaced by the appropriate spacecraft number.

The variable names for the data sets at the other magnetic field time resolutions are similar with FULL replaced by 5VPS, for 5 vectors/second data, and SPIN for spin averaged data.

Additionally, a reduced set of parameters from the calibration file – comprising spin-axis offset and gain, and spin-plane gain – are used in the production of Extended Mode data, as described in section 3.5.4, resulting in datasets with the following ID:

Cx_CP_FGM_EXTM: Extended Mode magnetic field at spin-resolution

4.4 Quality Control Procedures

The following three sections set out the procedures which are used to ensure the quality of the data products which are submitted to the CSA and the data products which can give information about the quality of the submitted data.

4.4.1 Summary of validation process

The following procedure is used to identify intervals of corrupt data which would otherwise be included in the magnetic field data products:

- The historical validation used in the production of the Prime Parameter data is reviewed and used as a starting point for data up to and including December 2005. No Prime Parameter validation records exist beyond this point.
- The 5 vectors/s CSA data product is then used to visually inspect the data. This visual inspection is conducted on the 5 vectors/s data files which cover the same period of time as the period covered by the data product which is to be validated and submitted to the CSA.
- The data for all four spacecraft are plotted together and time periods ranging from 30 minutes up to 3 hours examined, depending on the plasma environment being encountered at any particular time.
- Periods of data which contain spikes or variations which appear not to be natural may need to be inspected at full resolution to establish whether the features are corrupt data or just natural fluctuations.
- The times of HPA mode switches where offsets in the spin-axis field have been corrected for, observed on Cluster 1 only, are inspected for residual uncorrected vectors that appear as spikes. These can then be removed.
- Data periods which are found not to be valid are then removed from all final magnetic field data products and the validation data gap timings recorded in the validation product.
- Extended Mode datasets are validated by a number of methods as described in the User Guide, and as these are provided as auxiliary (or supplementary) data products – as distinct from the primary science products – these datasets are not included in the production of gap, validation or caveat files.

4.4.2 Caveat files

- Caveat files are produced for orbits of data where there is found to be higher than normal levels of residual spin tone after the calibration has been performed. A reason why there may be such levels of spin tone after the calibration has been done is if the calibration parameters are changing within an orbit. A typical example of when this may happen is in the region of an eclipse. Orbits where caveat files are required are found at the calibration stage when looking at the final spectrograms for each orbit and also at the validation stage when the data is being visually inspected. Generally caveat files are produced for each spacecraft during the eclipse seasons and they have been produced for a small number of other orbits when an operational event such as a manoeuvre causes visible effects in the calibrated magnetometer data. . Signal to noise ratio thresholds for Ranges 2 and 3 and spin power thresholds for the higher ranges, for the dayside and tail seasons, have been calculated so that high spin tone can be automatically identified. The Range 7 seven thresholds have not been firmly established due to limited data however all the thresholds for the other ranges have been found to be adequate on comparison with spectrograms. The spectrograms are generated during the Fourier analysis procedure to obtain the spin-plane calibration parameters.

4.5 Delivery Procedures

The generation of a calibration file for a particular data interval allows magnetic field data to be generated for that time interval at multiple resolutions. The validation process is similarly common to all magnetic field data products. The pre-generated magnetic field data products, with the supporting data sets defined in section 5, are therefore delivered to the CSA at the same time.

The method of delivery for all data products consists of placing the files in a designated directory on our data server and then running a script locally which securely transfers the data on to a specified delivery directory on the CSA system. This process occurs as the data products for at least the period of a month become available on our data server.

5 DATA PROVISION – SPECIFIC DESCRIPTIONS

5.1 Magnetic field full resolution

5.1.1 Format:

Cluster Exchange Format as defined in reference document
DS-QMW-TN-0010, [QMW-CDF]

5.1.2 Standards:

File format: CEF-2.0
Time standard: CCSDS ASCII time standard
Coordinate system: GSE
Magnetic field units: nT
Position units: km

5.1.3 Production Procedure:

This is a pre-generated product, produced directly from raw data, based on best available calibration information. For further details, see Section 4.3.1, the FGM User Guide (CAA-EST-UG-FGM) and FGM Calibration Report (CAA-EST-CR-FGM).

5.1.4 Quality Control Procedure:

The validation procedure is based on visual inspection of 5 vectors/second averaged data. For further information, see Section 4.4.1, and the FGM User Guide (CAA-EST-UG-FGM).

5.1.5 Delivery Procedure:

See Section 4.5

5.1.6 Product Specification

Cx_CP_FGM_FULL__yyyymmdd_hhmmss_yyyymmdd_hhmmss_Vnn.cef

Cx refers to the spacecraft number (1, 2, 3 or 4). yyyymmdd_hhmmss indicate the start and end times of the file. nn is the data product version number.

Each file contains the following data parameters

Time__C1_CP_FGM_FULL : Time (ISO_TIME)
half_interval__C1_CP_FGM_FULL : Half interval over which magnetic field is averaged (Units: s)
B_vec_xyz_gse__C1_CP_FGM_FULL : Magnetic field vector (3 components: GSE; Units: nT)
B_mag__C1_CP_FGM_FULL : Magnetic field magnitude (Units: nT)
sc_pos_xyz_gse__C1_CP_FGM_FULL : Spacecraft position (3 components: GSE; Units: km)
range__C1_CP_FGM_FULL : Instrument range (integer)
tm__ C1_CP_FGM_FULL : Telemetry mode (full number of vectors/second rounded to an integer)

tm__C1_CP_FGM_FULL can take the following values: 15, 18, 22, and 67 which correspond to telemetry modes A, B, C, and D respectively, described in Section 3.2, Table 2.

The data files for C2, 3 and 4 have similar variable names with C1 replaced by the appropriate spacecraft number.

5.1.7 Metadata Specification

5.1.7.1 Mission

The mission level metadata are given in the file called ”CL_CH_MISSION.ceh”. It is provided and maintained by the CSA team at ESTEC.

5.1.7.2 Observatory

The observatory level metadata are given in the files called ”C[i]_CH_OBS.ceh” where [i] is 1-4. There is one file for each spacecraft, and they are provided and maintained by the CSA team at ESTEC.

5.1.7.3 Experiment

```
START_META      =   EXPERIMENT
   ENTRY        =   "FGM"
END_META        =   EXPERIMENT
!
! Description of the experiment
!
START_META      =   EXPERIMENT_DESCRIPTION
   ENTRY        =   "Fluxgate Magnetometer"
END_META        =   EXPERIMENT_DESCRIPTION
!
! Name and coordinates of the PI, and possible earlier PIs
!
START_META      =   INVESTIGATOR_COORDINATES
   ENTRY        =   "Chris Carr>PI>c.m.carr@imperial.ac.uk"
END_META        =   INVESTIGATOR_COORDINATES
!
! List of standard reference documents for the experiment
```

```
!
START_META     =   EXPERIMENT_REFERENCES
   ENTRY       =   "*CL_CD_CAA_FGM_ICD_0001_V0_4.pdf"
   ENTRY       =   "*CL_CD_FGM_USERMAN.pdf"
   ENTRY       =   "http://www.sp.ph.ic.ac.uk/Cluster/"
END_META       =   EXPERIMENT_REFERENCES
!
! Name, role and coordinates of experiment key personnel
!
START_META     =   EXPERIMENT_KEY_PERSONNEL
   ENTRY       =   "Chris Carr>PI>c.m.carr@imperial.ac.uk"
END_META       =   EXPERIMENT_KEY_PERSONNEL
!
! Miscellaneous information concerning the experiment
!
START_META     =   EXPERIMENT_CAVEATS
   ENTRY       =   "*CL_CQ_FGM_CAVF.txt"
END_META       =   EXPERIMENT_CAVEATS
```

5.1.7.4 Instrument

```
! The instrument used to collect the data
!
START_META     =   INSTRUMENT_NAME
   ENTRY       =   "FGM2"
END_META       =   INSTRUMENT_NAME

START_META     =   INSTRUMENT_DESCRIPTION
   ENTRY       =   "FGM Experiment on Cluster C2"
END_META       =   INSTRUMENT_DESCRIPTION

START_META     =   INSTRUMENT_TYPE
   ENTRY       =   "Magnetometer"
   ENTRY       =   "Flux_Feedback"
END_META       =   INSTRUMENT_TYPE
!
START_META     =   MEASUREMENT_TYPE
   ENTRY       =   "Magnetic_Field"
END_META       =   MEASUREMENT_TYPE

START_META     =   INSTRUMENT_CAVEATS
   ENTRY       =   "*C2_CQ_FGM_CAVF"
END_META       =   INSTRUMENT_CAVEATS
!
```

The INSTRUMENT_NAME, INSTRUMENT_DESCRIPTION and INSTRUMENT_CAVEATS metadata entries for FGM2, 3, and 4 on Cluster C2, C3 and C4 are the same as for FGM1, but with the appropriate spacecraft number.

5.1.7.5 Dataset

```
! A unique identifier of the dataset: full resolution data
!
START_META     =   DATASET_ID
   ENTRY       =   "C1_CP_FGM_FULL"
END_META       =   DATASET_ID
!
! Used to distinguish the type of dataset
```

```
!
START_META     =   DATA_TYPE
   ENTRY       =   "CP>CAA Parameter"
END_META       =   DATA_TYPE
!
! Short title for the dataset
!
START_META     =   DATASET_TITLE
   ENTRY       =   "Magnetic field, full resolution"
END_META       =   DATASET_TITLE
!
! Short description of the data product
!
START_META     =   DATASET_DESCRIPTION
   ENTRY       =   "This dataset contains full resolution measurements of
the magnetic field vector from the FGM "
   ENTRY       =   "experiment on the Cluster C1 spacecraft"
END_META       =   DATASET_DESCRIPTION
!
```

These are metadata entries for the full resolution magnetic field measurements from FGM1 on Cluster 1. FGM2, 3 and 4 have data entries of the same format, with the appropriate spacecraft number.

```
! Name of dataset contact
!
START_META     =   CONTACT_COORDINATES
   " Chris Carr>PI>c.m.carr@imperial.ac.uk"
END_META       =   CONTACT_COORDINATES
!
```

The minimum and maximum time interval between data samples depends on the mode of the instrument. The characteristic time will be the Normal Mode (NM) sampling rate.

```
! Characteristic time interval (in s) between data samples
!
START_META     =   TIME_RESOLUTION
   ENTRY       =   0.04461
END_META       =   TIME_RESOLUTION
!
! Maximum time interval (in s)
!
START_META     =   MIN_TIME_RESOLUTION
   ENTRY       =   0.04461
END_META       =   MIN_TIME_RESOLUTION
!
!
```

Minimum time resolution (longer interval between vectors) when the instrument is in NM

```
! Minimum time interval (in s)
!
START_META     =   MAX_TIME_RESOLUTION
   ENTRY       =   0.01487
END_META       =   MAX_TIME_RESOLUTION
!
!
```

Maximum time resolution (shorter interval between vectors) when the instrument is in Burst Mode (BM)

```
!
! Level of processing on the dataset
!
```

```
START_META      =    PROCESSING_LEVEL
   ENTRY        =    "Calibrated"
END_META        =    PROCESSING_LEVEL
!
! Acknowledgement
!
START_META      =    ACKNOWLEDGEMENT
   ENTRY        =    "Please acknowledge the FGM team and ESA Cluster Active
Archive in any publication based upon use of this data"
   ENTRY        =    https://doi.org/10.5270/esa-hxcrsz5
END_META        =    ACKNOWLEDGEMENT
!
! Caveats or ID of product that contains the caveats
!
START_META      =    DATASET_CAVEATS
   ENTRY        =
"*C1_CQ_FGM_CAVEATS__yyyymmdd_hhmmss_yyyyddmm_hhmmss.cef"
END_META        =    DATASET_CAVEATS
!
```

The caveats associated with each data set are listed in the instrument caveat file

```
! Logical file ID for this instance of the file
!
START_META      =    LOGICAL_FILE_ID
   ENTRY        =    "C1_CP_FGM_FULL__yyyymmdd_hhmmss_yyyymmdd_hhmmss"
END_META        =    LOGICAL_FILE_ID
!
```

The time coverage of the file is defined in the filename. The DATASET_CAVEATS and LOGICAL_FILE_ID metadata entries for FGM 2, 3 and 4 have data entries of the same format with the appropriate spacecraft number. The INSTRUMENT_CAVEATS and DATASET_CAVEATS refer to the same file.

```
! Version identifier for this instance of the data
!
START_META      =    VERSION_NUMBER
   ENTRY        =    "01"
END_META        =    VERSION_NUMBER
!
```

The version number might change from version 1.

```
!
! Version identifier for this instance of the data
!
START_META      =    DATASET_VERSION
   ENTRY        =    "01"
END_META        =    DATASET_VERSION
!
! File format
!
START_META      =    FILE_TYPE
   ENTRY        =    "CEF"
END_META        =    FILE_TYPE
!
! Metadata specification used for this file
!
START_META      =    METADATA_TYPE
   ENTRY        =    "CAA"
END_META        =    METADATA_TYPE
!
```

```
! Version identifier for the metadata specification
!
START_META      =   METADATA_VERSION
   ENTRY        =   "2_0"
END_META        =   METADATA_VERSION
!
! Time span covered by this file
!
START_META      =   FILE_TIME_SPAN
   VALUE_TYPE   =   ISO_TIME_RANGE
   ENTRY        =   2004-01-01T00:00:00Z/2004-01-01T23:59:59Z
END_META        =   FILE_TIME_SPAN
!
! Date when the file was created
!
START_META      =   GENERATION_DATE
   VALUE_TYPE   =   ISO_TIME
   ENTRY        =   2004-11-19T09:10:16Z
END_META        =   GENERATION_DATE
!
! Caveats or dataset ID containing file caveats
!
START_META      =   FILE_CAVEATS
   ENTRY        =   "File specific caveats will be inserted here"
END_META        =   FILE_CAVEATS
```

5.1.7.6 Parameter

Each file contains the following parameters:

Time__C1_CP_FGM_FULL : Time (ISO_TIME)
half_interval__C1_CP_FGM_FULL : Half interval over which magnetic field is averaged (Units: s)
B_vec_xyz_gse__C1_CP_FGM_FULL : Magnetic field vector (3 components: GSE; Units: nT)
B_mag__C1_CP_FGM_FULL : Magnetic field magnitude (Units: nT)
sc_pos_xyz_gse__C1_CP_FGM_FULL : Spacecraft position (3 components: GSE; Units: km)
range__C1_CP_FGM_FULL : Instrument range (integer)
tm__ C1_CP_FGM_FULL : Telemetry mode (full number of vectors/second rounded to an integer)

tm__C1_CP_FGM_FULL can take the following values: 15, 18, 22, and 67 which correspond to telemetry modes A, B, C, and D respectively, described in Section 3.2, Table 2.

The data files for C2, 3 and 4 have similar variable names with C1 replaced by the appropriate spacecraft number.

```
START_VARIABLE   =   time_tags__C1_CP_FGM_FULL
    !
    ! Parameter ID
    !
    ! Type of parameter
    PARAMETER_TYPE      = "Support_Data"
    !
    ! Short description of the parameters
    CATDESC             = "Interval centred time tag"
    !
    ! The units of the parameter
    UNITS               = "s"
    !
    ! Ratio of data unit to SI unit (see section 6.8 of MDD)
```

```
    SI_CONVERSION        = "1.0>s"
    !
    ! Number of elements in each dimension
    SIZES                = 1
    !
    ! Type of value (may be used to assist conversion from ASCII to binary)
    VALUE_TYPE           = ISO_TIME
    !
    ! Number of decimal digits required to preserve precision of parameter
    SIGNIFICANT_DIGITS   = 24
    !
    ! Fill value used when data value is bad or missing
    FILLVAL              = 9999-12-31T23:59:59Z
    !
    ! Label discriminating the parameter (use LABELAXIS for axis)
    FIELDNAM             = "Universal Time"
    !
    ! Short character string used to label y-axis
    LABLAXIS             = "UT"
    !
    ! Value or variable added to define top of depend bin
    DELTA_PLUS           = half_interval__C1_CP_FGM_FULL
    !
    ! Value or variable subtracted to define bottom of depend bin
    DELTA_MINUS          = half_interval__C1_CP_FGM_FULL
END_VARIABLE    =  time_tags__C1_CP_FGM_FULL
!
!
START_VARIABLE  =  half_interval__C1_CP_FGM_FULL
    !
    ! Parameter ID
    !
    ! Type of parameter
    PARAMETER_TYPE       = "Support_Data"
    !
    ! Short description of the parameters
    CATDESC              = "Half averaging interval length"
    !
    ! The units of the parameter
    UNITS                = "s"
    !
    ! Ratio of data unit to SI unit (see section 6.8 of MDD)
    SI_CONVERSION        = "1.0>s"
    !
    ! Number of elements in each dimension
    SIZES                = 1
    !
    ! Type of value (may be used to assist conversion from ASCII to binary)
    VALUE_TYPE           = FLOAT
    !
    ! Number of decimal digits required to preserve precision of parameter
    SIGNIFICANT_DIGITS   = 6
    !
    ! Fill value used when data value is bad or missing
    FILLVAL              = -1e30
    !
    ! Label discriminating the parameter (use LABELAXIS for axis)
    FIELDNAM             = "Half width of averaging interval"
    !
```

```
    ! Short character string used to label y-axis
    LABLAXIS            = "s"
    !
END_VARIABLE    =  half_interval__C1_CP_FGM_FULL
!
!
START_VARIABLE  =  B_vec_xyz_gse__C1_CP_FGM_FULL
    !
    ! Parameter ID
    !
    ! Type of parameter
    PARAMETER_TYPE      = "Data"
    !
    ! Entity whose property is measured
    ENTITY              = "Magnetic_Field"
    !
    ! Property of the entity that is being measured
    PROPERTY            = "Vector"
    !
    FLUCTUATIONS      = "Waveform"
    !
    ! Short description of the parameters
    CATDESC             = "Cluster C1, Magnetic Field Vector, full
resolution in GSE"
    !
    ! The units of the parameter
    UNITS               = "nT"
    !
    ! Ratio of data unit to SI unit (see section 6.8 of MDD)
    SI_CONVERSION       = "1.0E-9>T"
    !
    ! Order of parameter, 0=scalar, 1=vector, 2=tensor of rank 2
    TENSOR_ORDER        = "1"
    !
    ! Co-ordinate system in which this parameter has been measured
    COORDINATE_SYSTEM   = "GSE>Geocentric Solar Ecliptic"
    !
    ! Describes first dimension of vector/tensor
    REPRESENTATION_1    = "x", "y", "z"
    !
    ! Number of elements in each dimension
    SIZES               = 3
    !
    ! Type of value (may be used to assist conversion from ASCII to binary)
    VALUE_TYPE          = FLOAT
    !
    ! Number of decimal digits required to preserve precision of parameter
    SIGNIFICANT_DIGITS  = 6
    !
    ! Fill value used when data value is bad or missing
    FILLVAL             = -1e30
    !
    ! Quality of the parameter
    QUALITY             = 3
    !
    ! Label discriminating the parameter (use LABELAXIS for axis)
    FIELDNAM            = "Cluster C1, Magnetic Field Vector, full
resolution in GSE"
    !
```

```
    ! Short character string used to label y-axis
    LABLAXIS             = "Mag Field"
    !
    ! Indicates the dependent variable for the record varying dimension
(usually time)
    DEPEND_0             = time_tags__C1_CP_FGM_FULL
    !
    ! Indicates the labels for first dimension
    LABEL_1              = "Bx", "By", "Bz"
END_VARIABLE    =  B_vec_xyz_gse__C1_CP_FGM_FULL
!
!
START_VARIABLE  =  B_mag__C1_CP_FGM_FULL
    !
    ! Parameter ID
    !
    ! Type of parameter
    PARAMETER_TYPE       = "Data"
    !
    ! Entity whose property is measured
    ENTITY               = "Magnetic_Field"
    !
    ! Property of the entity that is being measured
    PROPERTY             = "Magnitude"
    !
    FLUCTUATIONS       = "Waveform"
    !
    ! Short description of the parameters
    CATDESC              = "Cluster C1, Magnetic Field Magnitude, full
resolution"
    !
    ! The units of the parameter
    UNITS                = "nT"
    !
    ! Ratio of data unit to SI unit (see section 6.8 of MDD)
    SI_CONVERSION        = "1.0E-9>T"
    !
    ! Order of parameter, 0=scalar, 1=vector, 2=tensor of rank 2
    TENSOR_ORDER         = "0"
    !
    ! Number of elements in each dimension
    SIZES                = 1
    !
    ! Type of value (may be used to assist conversion from ASCII to binary)
    VALUE_TYPE           = FLOAT
    !
    ! Number of decimal digits required to preserve precision of parameter
    SIGNIFICANT_DIGITS   = 6
    !
    ! Fill value used when data value is bad or missing
    FILLVAL              = -1.0E30
    !
    ! Quality of the parameter
    QUALITY              = 3
    !
    ! Label discriminating the parameter (use LABELAXIS for axis)
    FIELDNAM             = "Cluster C1, Magnetic Field Magnitude, full
resolution"
    !
```

```
    ! Short character string used to label y-axis
    LABLAXIS            = "B"
    !
    ! Indicates the dependent variable for the record varying dimension
(usually time)
    DEPEND_0            = time_tags__C1_CP_FGM_FULL
END_VARIABLE     =  B_mag__C1_CP_FGM_FULL
!
!
START_VARIABLE   =  sc_pos_xyz_gse__C1_CP_FGM_FULL
    !
    ! Parameter ID
    !
    ! Type of parameter
    PARAMETER_TYPE      = "Data"
    !
    !
    ! Entity whose property is measured
    ENTITY              = "Other1"
    !
    ! Property of the entity that is being measured
    PROPERTY            = "Vector"
    !
    ! Short description of the parameters
    CATDESC             = "Position of Cluster C1 in GSE"
    !
    ! The units of the parameter
    UNITS               = "km"
    !
    ! Ratio of data unit to SI unit (see section 6.8 of MDD)
    SI_CONVERSION       = "1.0E3>m"
    !
    ! Order of parameter, 0=scalar, 1=vector, 2=tensor of rank 2
    TENSOR_ORDER        = "1"
    !
    ! Co-ordinate system in which this parameter has been measured
    COORDINATE_SYSTEM   = "GSE>Geocentric Solar Ecliptic"
    !
    ! Describes first dimension of vector/tensor
    REPRESENTATION_1    = "x", "y", "z"
    !
    ! Number of elements in each dimension
    SIZES               = 3
    !
    ! Type of value (may be used to assist conversion from ASCII to binary)
    VALUE_TYPE          = FLOAT
    !
    ! Number of decimal digits required to preserve precision of parameter
    SIGNIFICANT_DIGITS  = 7
    !
    ! Fill value used when data value is bad or missing
    FILLVAL             = -1.0E30
    ! Quality of the parameter
    QUALITY             = 0
    !
    ! Label discriminating the parameter (use LABELAXIS for axis)
    FIELDNAM            = "Position of Cluster C1 in GSE"
    !
    ! Short character string used to label y-axis
```

```
    LABLAXIS            = "Position"
    !
    ! Indicates the dependent variable for the record varying dimension
(usually time)
    DEPEND_0            = time_tags__C1_CP_FGM_FULL
    !
    ! Indicates the labels for first dimension
    LABEL_1             = "x", "y", "z"
END_VARIABLE     =  sc_pos_xyz_gse__C1_CP_FGM_FULL
!
!
START_VARIABLE   =  range__C1_CP_FGM_FULL
    !
    ! Parameter ID
    !
    ! Type of parameter
    PARAMETER_TYPE      = "Support_Data"
    !
    ! Short description of the parameters
    CATDESC             = "Cluster C1, FGM instrument range, defined on
full resolution time line"
    !
    ! The units of the parameter
    UNITS               = "Unitless"
    !
    ! Order of parameter, 0=scalar, 1=vector, 2=tensor of rank 2
    TENSOR_ORDER        = "0"
    !
    ! Number of elements in each dimension
    SIZES               = 1
    !
    ! Type of value (may be used to assist conversion from ASCII to binary)
    VALUE_TYPE          = INT
    !
    ! Number of decimal digits required to preserve precision of parameter
    SIGNIFICANT_DIGITS  = 1
    !
    ! Fill value used when data value is bad or missing
    FILLVAL             = -9
    !
    ! Label discriminating the parameter (use LABELAXIS for axis)
    FIELDNAM            = "Cluster C1, FGM Instrument Range, on full
resolution time line"
    !
    ! Short character string used to label y-axis
    LABLAXIS            = "Range"
    !
    ! Indicates the dependent variable for the record varying dimension
(usually time)
    DEPEND_0            = time_tags__C1_CP_FGM_FULL
END_VARIABLE     =  range__C1_CP_FGM_FULL
!
!
START_VARIABLE   =  tm__C1_CP_FGM_FULL
    !
    ! Parameter ID
    !
    ! Type of parameter
    PARAMETER_TYPE      = "Support_Data"
```

```
    !
    ! Short description of the parameters
    CATDESC              = "Cluster C1, FGM telemetry mode (burst
mode/normal mode) on full resolution time line"
    !
    ! The units of the parameter
    UNITS                = "Unitless"
    !
    ! Order of parameter, 0=scalar, 1=vector, 2=tensor of rank 2
    TENSOR_ORDER         = "0"
    !
    ! Number of elements in each dimension
    SIZES                = 1
    !
    ! Type of value (may be used to assist conversion from ASCII to binary)
    VALUE_TYPE           = INT
    !
    ! Number of decimal digits required to preserve precision of parameter
    SIGNIFICANT_DIGITS   = 2
    !
    ! Fill value used when data valueis bad or missing
    FILLVAL              = -99
    !
     ! Label discriminating the parameter (use LABELAXIS for axis)
    FIELDNAM             = "Cluster C1, telemetry mode on full resolution
time line"
    !
    ! Short character string used to label y-axis
    LABLAXIS             = "TM"
    !
    ! Indicates the dependent variable for the record varying dimension
(usually time)
    DEPEND_0             = time_tags__C1_CP_FGM_FULL
END_VARIABLE    =  tm__C1_CP_FGM_FULL
```

5.2 Magnetic field 5 vectors/second

5.2.1 Format:

As described in Section 5.1.1

5.2.2 Standards:

As described in section 5.1.2

5.2.3 Production Procedure:

As described in section 5.1.3

5.2.4 Quality Control Procedure:

As described in section 5.1.4

5.2.5 Delivery Procedure:

As described in section 5.1.5

5.2.6 Product Specification

Cx_CP_FGM_5VPS__yyyymmdd_hhmmss_yyyymmdd_hhmmss_Vnn.cef

Cx refers to the spacecraft number (1, 2, 3 or 4). yyyymmdd_hhmmss indicate the start and end times of the file. nn is the data product version number.

Each file contains the following parameters:

Time__C1_CP_FGM_5VPS	: Time (ISO_TIME)
half_interval__C1_CP_FGM_5VPS	: Half interval over which magnetic field is averaged (Units: s)
B_vec_xyz_gse__C1_CP_FGM_5VPS	: Magnetic field vector (3 components: GSE; Units: nT)
B_mag__C1_CP_FGM_5VPS	: Magnetic field magnitude (Units: nT)
sc_pos_xyz_gse__C1_CP_FGM_5VPS	: Spacecraft position (3 components: GSE; Units: km)
range__C1_CP_FGM_5VPS	: Instrument range (integer)
tm__ C1_CP_FGM_5VPS	: Telemetry mode (integer); coding TDB

The data files for C2, 3 and 4 have similar variable names with C1 replaced by the appropriate spacecraft number.

5.2.7 Metadata Specification

5.2.7.1 Mission

As described in Section 5.1.7.1

5.2.7.2 Observatory

As described in Section 5.1.7.2

5.2.7.3 Experiment

As described in Section 5.1.7.3

5.2.7.4 Instrument

As described in Section 5.1.7.4

5.2.7.5 Dataset

```
! A unique identifier of the dataset: data averaged to 5 vectors/second
!
START_META     =   DATASET_ID
   ENTRY       =   "C1_CP_FGM_5VPS"
END_META       =   DATASET_ID
!
! Used to distinguish the type of dataset
!
START_META     =   DATA_TYPE
   ENTRY       =   "CP>CAA Parameter"
END_META       =   DATA_TYPE
!
! Short title for the dataset
!
START_META     =   DATASET_TITLE
   ENTRY       =   "Magnetic field, 5 vectors/second resolution"
END_META       =   DATASET_TITLE
!
! Short description of the data product
!
START_META     =   DATASET_DESCRIPTION
```

```
   ENTRY        =   "This dataset contains 5 vectors/sec measurements of the
magnetic field vector from the FGM "
   ENTRY        =   "experiment on the Cluster C1 spacecraft"
END_META        =   DATASET_DESCRIPTION
!
```

These are metadata entries for the 5 vectors/second magnetic field measurements from FGM1 on Cluster 1. FGM2, 3 and 4 have data entries of the same format, with the appropriate spacecraft number.

```
! Name of dataset contact
!
START_META      =   CONTACT_COORDINATES
   ENTRY        =   " Chris Carr>PI>c.m.carr@imperial.ac.uk "
END_META        =   CONTACT_COORDINATES
!

! Characteristic time interval (in s) between data samples
!
START_META      =   TIME_RESOLUTION
   ENTRY        =   0.2
END_META        =   TIME_RESOLUTION
!
! Maximum time interval (in s)
!
START_META      =   MIN_TIME_RESOLUTION
   ENTRY        =   0.2
END_META        =   MIN_TIME_RESOLUTION
!
! Minimum time interval (in s)
!
START_META      =   MAX_TIME_RESOLUTION
   ENTRY        =   0.2
END_META        =   MAX_TIME_RESOLUTION
!
! Level of processing on the dataset
!
START_META      =   PROCESSING_LEVEL
   ENTRY        =   "Calibrated"
END_META        =   PROCESSING_LEVEL
!
! Acknowledgement
!
START_META      =   ACKNOWLEDGEMENT
   ENTRY        =   "Please acknowledge the FGM team and ESA Cluster Active
Archive in any publication based upon use of this data"
   ENTRY        =   https://doi.org/10.5270/esa-hxcrsz5
END_META        =   ACKNOWLEDGEMENT
!
! Cavetas or ID of product that contains the caveats
!
START_META      =   DATASET_CAVEATS
   ENTRY        =   "*C1_CQ_FGM_CAVEATS__yyyymmdd_hhmmss_yyyymmdd_hhmmss"
END_META        =   DATASET_CAVEATS
```

The caveats associated with each data set are listed in the instrument caveat file

```
!
! Logical file ID for this instance of the file
!
START_META      =   LOGICAL_FILE_ID
```

```
   ENTRY        =   "C1_CP_FGM_5VPS__yyyymmdd_hhmmss_yyyymmdd_hhmmss"
END_META        =   LOGICAL_FILE_ID
!
```

The time coverage of the file is defined in the filename. The DATASET_CAVEATS and LOGICAL_FILE_ID metadata entries for FGM2, 3 and 4 have data entries of the same format with the appropriate spacecraft number.

```
! Version identifier for this instance of the data
!
START_META      =   VERSION_NUMBER
   ENTRY        =   "01"
END_META        =   VERSION_NUMBER
```

The version number might change from V01.

```
!
! Version identifier for this instance of the data
!
START_META      =   DATASET_VERSION
   ENTRY        =   "01"
END_META        =   DATASET_VERSION
!
! File format
!
START_META      =   FILE_TYPE
   ENTRY        =   "CEF"
END_META        =   FILE_TYPE
!
! Metadata specification used for this file
!
START_META      =   METADATA_TYPE
   ENTRY        =   "CAA"
END_META        =   METADATA_TYPE
!
! Version identifier for the metadata specification
!
START_META      =   METADATA_VERSION
   ENTRY        =   "2_0"
END_META        =   METADATA_VERSION
!
! Time span covered by this file
!
START_META      =   FILE_TIME_SPAN
   VALUE_TYPE   =   ISO_TIME_RANGE
   ENTRY        =   2004-01-01T00:00:00Z/2004-01-01T23:59:59Z
END_META        =   FILE_TIME_SPAN
!
! Date when the file was created

! Caveats or dataset ID containing file caveats
!
START_META      =   FILE_CAVEATS
   ENTRY        =   "File specific caveats will be inserted here"
END_META        =   FILE_CAVEATS
```

5.2.7.6 Parameter

Each file contains the following parameters:

Time__C1_CP_FGM_5VPS : Time (ISO_TIME)
half_interval__C1_CP_FGM_5VPS : Half interval over which magnetic field is averaged (Units: s)
B_vec_xyz_gse__C1_CP_FGM_5VPS : Magnetic field vector (3 components: GSE; Units: nT)
B_mag__C1_CP_FGM_5VPS : Magnetic field magnitude (Units: nT)
sc_pos_xyz_gse__C1_CP_FGM_5VPS : Spacecraft position (3 components: GSE; Units: km)
range__C1_CP_FGM_5VPS : Instrument range (integer)
tm__ C1_CP_FGM_5VPS : Telemetry mode (integer); coding TDB

The data files for C2, 3 and 4 have similar variable names with C1 replaced by the appropriate spacecraft number.

The metadata for these variables are as described in Section 5.1.7.6

5.3 Magnetic field spin resolution

5.3.1 Format:

As described in Section 5.1.1

5.3.2 Standards:

As described in Section 5.1.2

5.3.3 Production Procedure:

As described in Section 5.1.3

5.3.4 Quality Control Procedure:

As described in Section 5.1.4

5.3.5 Delivery Procedure:

As described in Section 5.1.6

5.3.6 Product Specification

Cx_CP_FGM_SPIN__yyyymmdd_hhmmss_yyyymmdd_hhmmss_Vnn.cef

Cx refers to the spacecraft number (1, 2, 3 or 4). yyyymmdd_hhmmss indicate the start and end times of the file. nn is the data product version number.

Each file contains the following parameters:

Time__C1_CP_FGM_SPIN : Time (ISO_TIME)
half_interval__C1_CP_FGM_SPIN : Half interval over which magnetic field is averaged (Units: s)
B_vec_xyz_gse__C1_CP_FGM_SPIN : Magnetic field vector (3 components: GSE; Units: nT)
B_mag__C1_CP_FGM_SPIN : Magnetic field magnitude (Units: nT)
sc_pos_xyz_gse__C1_CP_FGM_SPIN : Spacecraft position (3 components: GSE; Units: km)
range__C1_CP_FGM_SPIN : Instrument range (integer)
tm__ C1_CP_FGM_SPIN : Telemetry mode (integer); coding TBD

The data files for C2, 3 and 4 have similar variable names with C1 replaced by the appropriate spacecraft number.

5.3.7 Metadata Specification

5.3.7.1 Mission

As described in Section 5.1.7.1

5.3.7.2 Observatory

As described in Section 5.1.7.2

5.3.7.3 Experiment

As described in Section 5.1.7.3

5.3.7.4 Instrument

As described in Section 5.1.7.4

5.3.7.5 Dataset

```
! A unique identifier of the dataset: spin resolution data
!
START_META     =   DATASET_ID
   ENTRY       =   "C1_CP_FGM_SPIN"
END_META       =   DATASET_ID
!
! Used to distinguish the type of dataset
!
START_META     =   DATA_TYPE
   ENTRY       =   "CP>CAA Parameter"
END_META       =   DATA_TYPE
!
! Short title for the dataset
!
START_META     =   DATASET_TITLE
   ENTRY       =   "Magnetic field, spin resolution"
END_META       =   DATASET_TITLE
!
! Short description of the data product
!
START_META     =   DATASET_DESCRIPTION
   ENTRY       =   "This dataset contains spin resolution measurements of
the magnetic field vector from the FGM "
   ENTRY       =   "experiment on the Cluster C1 spacecraft"
END_META       =   DATASET_DESCRIPTION
!
```

These are metadata entries for spin resolution magnetic field measurements from FGM1 on Cluster 1. FGM2, 3 and 4 have data entries of the same format, with the appropriate spacecraft number.

```
! Name of dataset contact
!
START_META     =   CONTACT_COORDINATES
   ENTRY       =   "Chris Carr>PI>c.m.carr@imperial.ac.uk"
END_META       =   CONTACT_COORDINATES
!
```

The minimum and maximum time interval between data samples depends on the spin rate of the spacecraft. The values given are for the tolerances in spin rate defined within the mission.

```
! Characteristic time interval (in s) between data samples
!
START_META     =   TIME_RESOLUTION
   ENTRY       =   4
END_META       =   TIME_RESOLUTION
!
```

```
! Maximum time interval (in s)
!
START_META      =   MIN_TIME_RESOLUTION
   ENTRY        =   4.412
END_META        =   MIN_TIME_RESOLUTION
!
! Minimum time interval (in s)
!
START_META      =   MAX_TIME_RESOLUTION
   ENTRY        =   3.636
END_META        =   MAX_TIME_RESOLUTION
!
! Level of processing on the dataset
!
START_META      =   PROCESSING_LEVEL
   ENTRY        =   "Calibrated"
END_META        =   PROCESSING_LEVEL
!
! Acknowledgement
!
START_META      =   ACKNOWLEDGEMENT
   ENTRY        =   "Please acknowledge the FGM team and ESA Cluster Active
Archive in any publication based upon use of this data"
   ENTRY        =   https://doi.org/10.5270/esa-hxcrsz5
END_META        =   ACKNOWLEDGEMENT
!
! Cavetas or ID of product that contains the caveats
!
START_META      =   DATASET_CAVEATS
   ENTRY        =   "*C1_CQ_FGM_CAVEATS__yyyymmdd_hhmmss_yyyymmdd_hhmmss"
END_META        =   DATASET_CAVEATS
```

The caveats associated with each data set are listed in the instrument caveat file

```
!
! Logical file ID for this instance of the file
!
START_META      =   LOGICAL_FILE_ID
   ENTRY        =   "C1_CP_FGM_SPIN__yyyymmdd_hhmmss_yyyymmdd_hhmmss"
END_META        =   LOGICAL_FILE_ID
!
```

The time coverage of the file is defined in the filename. The DATASET_CAVEATS and LOGICAL_FILE_ID metadata entries for FGM2, 3 and 4 have data entries of the same format with the appropriate spacecraft number.

```
! Version identifier for this instance of the data
!
START_META      =   VERSION_NUMBER
   ENTRY        =   "01"
END_META        =   VERSION_NUMBER
!
```

The version number might change from V01.

```
!
! Version identifier for this instance of the data
!
START_META      =   DATASET_VERSION
   ENTRY        =   "01"
END_META        =   DATASET_VERSION
!
```

```
! File format
!
START_META     =   FILE_TYPE
   ENTRY       =   "CEF"
END_META       =   FILE_TYPE
!
! Metadata specification used for this file
!
START_META     =   METADATA_TYPE
   ENTRY       =   "CAA"
END_META       =   METADATA_TYPE
!
! Version identifier for the metadata specification
!
START_META     =   METADATA_VERSION
   ENTRY       =   "2_0"
END_META       =   METADATA_VERSION
!
! Time span covered by this file
!
START_META     =   FILE_TIME_SPAN
   VALUE_TYPE  =   ISO_TIME_RANGE
   ENTRY       =   2004-01-01T00:00:00Z/2004-01-01T23:59:59Z
END_META       =   FILE_TIME_SPAN
!
! Date when the file was created
!
START_META     =   GENERATION_DATE
   VALUE_TYPE  =   ISO_TIME
   ENTRY       =   2004-11-19T09:10:16Z
END_META       =   GENERATION_DATE
!
! Caveats or dataset ID containing file caveats
!
START_META     =   FILE_CAVEATS
   ENTRY       =   "File specific caveats will be inserted here"
END_META       =   FILE_CAVEATS
```

5.3.7.6 Parameter

Each file contains the following parameters:

Time__C1_CP_FGM_SPIN	: Time (ISO_TIME)
half_interval__C1_CP_FGM_SPIN	: Half interval over which magnetic field is averaged (Units: s)
B_vec_xyz_gse__C1_CP_FGM_SPIN	: Magnetic field vector (3 components: GSE; Units: nT)
B_mag__C1_CP_FGM_SPIN	: Magnetic field magnitude (Units: nT)
sc_pos_xyz_gse__C1_CP_FGM_SPIN	: Spacecraft position (3 components: GSE; Units: km)
range__C1_CP_FGM_SPIN	: Instrument range (integer)
tm__ C1_CP_FGM_SPIN	: Telemetry mode (integer); coding TDB

The data files for C2, 3 and 4 have similar variable names with C1 replaced by the appropriate spacecraft number.

The metadata for these variables are as described in Section 5.1.7.6

5.4 Extended Mode

5.4.1 Format:

As described in Section 5.1.1

5.4.2 Standards:

As described in Section 5.1.2

5.4.3 Production Procedure:

Extended Mode datasets are produced on a case-by-case basis as described in the FGM User Guide

5.4.4 Quality Control Procedure:

See FGM User Guide

5.4.5 Delivery Procedure:

As described in Section 5.1.6

5.4.6 Product Specification

Cx_CP_FGM_EXTM__yyyymmdd_hhmmss_yyyymmdd_hhmmss_Vnn.cef

Cx refers to the spacecraft number (1, 2, 3 or 4). yyyymmdd_hhmmss indicate the start and end times of the file. nn is the data product version number.

Each file contains the following parameters:

Time__C1_CP_FGM_EXTM	: Time (ISO_TIME)
half_interval__C1_CP_FGM_EXTM	: Half interval over which magnetic field is averaged (Units: s)
B_vec_xyz_gse__C1_CP_FGM_EXTM	: Magnetic field vector (3 components: GSE; Units: nT)
B_mag__C1_CP_FGM_EXTM	: Magnetic field magnitude (Units: nT)
sc_pos_xyz_gse__C1_CP_FGM_EXTM	: Spacecraft position (3 components: GSE; Units: km)
range__C1_CP_FGM_EXTM	: Instrument range (integer)
tm__C1_CP_FGM_EXTM	: Telemetry mode (integer); fill-value

The data files for C2, 3 and 4 have similar variable names with C1 replaced by the appropriate spacecraft number.

5.4.7 Metadata Specification

5.4.7.1 Mission

As described in Section 5.1.7.1

5.4.7.2 Observatory

As described in Section 5.1.7.2

5.4.7.3 Experiment

As described in Section 5.1.7.3

5.4.7.4 Instrument

As described in Section 5.1.7.4

5.4.7.5 Dataset

```
! A unique identifier of the dataset: spin resolution data
!
START_META     =   DATASET_ID
   ENTRY       =   "C1_CP_FGM_EXTM"
END_META       =   DATASET_ID
!
! Used to distinguish the type of dataset
!
START_META     =   DATA_TYPE
   ENTRY       =   "CP>CAA Parameter"
END_META       =   DATA_TYPE
!
! Short title for the dataset
!
START_META     =   DATASET_TITLE
   ENTRY       =   "Magnetic field, Extended Mode"
END_META       =   DATASET_TITLE
!
! Short description of the data product
!
START_META     =   DATASET_DESCRIPTION
   ENTRY       =   "C1 FGM Extended Mode spin resolution magnetic field vectors"
   ENTRY       =   "Extended Mode was used when science data was not recorded on the spacecraft"
   ENTRY       =   "Samples processed and stored in FGM memory then downlinked during BM3 intervals"
   ENTRY       =   "Calibration and timing inferior to FGM primary products - refer to FGM User Guide"
END_META       =   DATASET_DESCRIPTION
!
```

These are metadata entries for spin resolution magnetic field measurements from FGM1 on Cluster 1. FGM2, 3 and 4 have data entries of the same format, with the appropriate spacecraft number.

```
! Name of dataset contact
!
START_META     =   CONTACT_COORDINATES
   ENTRY       =   "Chris Carr>PI>c.m.carr@imperial.ac.uk"
END_META       =   CONTACT_COORDINATES
!
```

The minimum and maximum time interval between data samples depends on the spin rate of the spacecraft. The values given are for the tolerances in spin rate defined within the mission.

```
! Characteristic time interval (in s) between data samples
!
START_META     =   TIME_RESOLUTION
   ENTRY       =   4
END_META       =   TIME_RESOLUTION
!
! Maximum time interval (in s)
!
START_META     =   MIN_TIME_RESOLUTION
   ENTRY       =   4.412
END_META       =   MIN_TIME_RESOLUTION
!
```

```
! Minimum time interval (in s)
!
START_META     =   MAX_TIME_RESOLUTION
   ENTRY       =   3.636
END_META       =   MAX_TIME_RESOLUTION
!
! Level of processing on the dataset
!
START_META     =   PROCESSING_LEVEL
   ENTRY       =   "Calibrated"
END_META       =   PROCESSING_LEVEL
!
! Acknowledgement
!
START_META     =   ACKNOWLEDGEMENT
   ENTRY       =   "Please acknowledge the FGM team and ESA Cluster Active
Archive in any publication based upon use of this data"
   ENTRY       =   https://doi.org/10.5270/esa-hxcrsz5
END_META       =   ACKNOWLEDGEMENT
!
! Caveats or ID of product that contains the caveats
!
START_META     =   DATASET_CAVEATS
   ENTRY       =   "*C1_CQ_FGM_EXTC"
END_META       =   DATASET_CAVEATS
```

This entry is retained for purposes of consistency and compatibility, however caveats are not generated for Extended Mode datasets

```
!
! Logical file ID for this instance of the file
!
START_META     =   LOGICAL_FILE_ID
   ENTRY       =   "C1_CP_FGM_EXTM__yyyymmdd_hhmmss_yyyymmdd_hhmmss"
END_META       =   LOGICAL_FILE_ID
!
```

The time coverage of the file is defined in the filename. The DATASET_CAVEATS and LOGICAL_FILE_ID metadata entries for FGM2, 3 and 4 have data entries of the same format with the appropriate spacecraft number.

```
! Version identifier for this instance of the data
!
START_META     =   VERSION_NUMBER
   ENTRY       =   "01"
END_META       =   VERSION_NUMBER
!
```

The version number might change from V01.

```
!
! Version identifier for this instance of the data
!
START_META     =   DATASET_VERSION
   ENTRY       =   "01"
END_META       =   DATASET_VERSION
!
! File format
!
START_META     =   FILE_TYPE
   ENTRY       =   "CEF"
END_META       =   FILE_TYPE
```

```
!
! Metadata specification used for this file
!
START_META     =   METADATA_TYPE
   ENTRY       =   "CAA"
END_META       =   METADATA_TYPE
!
! Version identifier for the metadata specification
!
START_META     =   METADATA_VERSION
   ENTRY       =   "2.0"
END_META       =   METADATA_VERSION
!
! Time span covered by this file
!
START_META     =   FILE_TIME_SPAN
   VALUE_TYPE  =   ISO_TIME_RANGE
   ENTRY       =   2004-01-01T00:00:00Z/2004-01-01T23:59:59Z
END_META       =   FILE_TIME_SPAN
!
! Date when the file was created
!
START_META     =   GENERATION_DATE
   VALUE_TYPE  =   ISO_TIME
   ENTRY       =   2004-11-19T09:10:16Z
END_META       =   GENERATION_DATE
!
! Caveats or dataset ID containing file caveats
!
START_META     =   FILE_CAVEATS
   ENTRY       =   "File specific caveats will be inserted here"
END_META       =   FILE_CAVEATS
```

This entry is retained for purposes of consistency and compatibility, however caveats are not generated for Extended Mode datasets

5.4.7.6 Parameter

Each file contains the following parameters:

Time__C1_CP_FGM_EXTM : Time (ISO_TIME)
half_interval__C1_CP_FGM_EXTM : Half interval over which magnetic field is averaged (Units: s)
B_vec_xyz_gse__C1_CP_FGM_EXTM : Magnetic field vector (3 components: GSE; Units: nT)
B_mag__C1_CP_FGM_EXTM : Magnetic field magnitude (Units: nT)
sc_pos_xyz_gse__C1_CP_FGM_EXTM : Spacecraft position (3 components: GSE; Units: km)
range__C1_CP_FGM_EXTM : Instrument range (integer)
tm__C1_CP_FGM_EXTM : Telemetry mode (integer); fill-value as described below

The data files for C2, 3 and 4 have similar variable names with C1 replaced by the appropriate spacecraft number.

The metadata for these variables are as described in Section 5.1.7.6, with the exception of the ‘Telemetry mode’ which takes the fill-value of ‘22’. The parameter has no interpretation for the Extended Mode dataset, however the fill-value is used to ensure consistency and software compatibility.

5.5 Data Processing Software

In principle software for on demand processing could be made available but there is no need for it at the moment.

5.6 Calibration files

5.6.1 Format:

ASCII. See Section 4.3.2..

5.6.2 Standards:

Defined by FGM Data Processing Handbook

5.6.3 Production Procedure:

See Section 4.3.1.

5.6.4 Quality Control Procedure:

The quality control procedure consists of the validation process, the production of caveat files and the production of calibration accuracy files all of which are described in section 4.4.

5.6.5 Delivery Procedure:

As described in section 5.1.5

5.6.6 Product Specification

Cx_CC_FGM_CALF__yyyymmdd_hhmmss_yyyymmdd_hhmmss_Vxx.fgmcal

Cx refers to the spacecraft number (1,2, 3 or 4). yyyymmdd_hhmmss indicate the start and end validity of the file. Vxx indicates the Version number.

5.6.7 Metadata Specification

5.6.7.1 Mission

As described in Section 5.1.7.1

5.6.7.2 Observatory

As described in Section 5.1.7.2

5.6.7.3 Experiment

As described in Section 5.1.7.3

5.6.7.4 Instrument

As described in Section 5.1.7.4

5.6.7.5 Dataset

```
! Name of dataset contact
!
START_META     =   CONTACT_COORDINATES
   ENTRY       =   "Chris Carr>PI>c.m.carr@imperial.ac.uk"
END_META       =   CONTACT_COORDINATES
!

! Caveats or ID of product that contains the caveats
!
START_META     =   DATASET_CAVEATS
   ENTRY       =   "*C1_CQ_FGM_CAVEATS__"
END_META       =   DATASET_CAVEATS
!
! Logical file ID for this instance of the file
!
START_META     =   LOGICAL_FILE_ID
   ENTRY      = "Cx_CC_FGM_CALF__yyyymmdd_hhmmss_yyyymmdd_hhmmss_Vxx.fgmcal"
END_META       =   LOGICAL_FILE_ID
!
```

The DATASET_CAVEATS and LOGICAL_FILE_ID metadata entries for FGM2, 3 and 4 have data entries of the same format with the appropriate spacecraft number.

`METADATA: FILE_TIME_SPAN`

The time coverage of the file is defined in the filename. The calibration file has validity between the first time in the filename: yyyyddmm_hhmmss and the second time: yyyyddmm_hhmmss.

`METADATA: VERSION_NUMBER`

The version number is described by the Vxx part of the filename.

`METADATA: FILE_TYPE`

The file format is ASCII, described the FGM ICD and Gloag J. M., E. A. Lucek, L.–N. Alconcel, A. Balogh, P. Brown, C. M. Carr, C. N. Dunford, T. Oddy, J. Soucek, FGM data products in the CAA, in *The Cluster Active Archive - Studying the Earth's Space Plasma Environment,* edited by H. Laakso, M.G.G.T. Taylor, C.P. Escoubet, Springer, 2010.. The calibration file is used as part of the FGM data processing software.

Calibration files have a file encoding format of version 1.0

```
! Metadata specification used for this file
!
START_META     =   METADATA_TYPE
   ENTRY       =   "CAA"
END_META       =   METADATA_TYPE
!
! Version identifier for the metadata specification
!
START_META     =   METADATA_VERSION
   ENTRY       =   "2_0"
END_META       =   METADATA_VERSION
!
```

5.7 Experiment caveat files

5.7.1 Format:

The caveat file at the experiment level is a static, ascii, free format text file.

5.7.2 Standards:

N/A

5.7.3 Production Procedure:

The caveat file contains general information relevant to all FGM instruments. They contain time-tagged caveats that apply to the whole FGM experiment. As this is not suited to the FGM experiment they are static files with valid headers that are empty. Time-tagged caveats for each instrument are defined in the Instrument caveat files (Section 5.7), which also apply to each FGM magnetic field data set.

5.7.4 Quality Control Procedure:

N/A

5.7.5 Delivery Procedure:

As described in section 5.1.5

5.7.6 Product Specification:

CL_CQ_FGM_CAVF.txt

5.7.7 Metadata Specification:

5.7.7.1 Mission

As described in Section 5.1.7.1

5.7.7.2 Observatory

As described in Section 5.1.7.2

5.7.7.3 Experiment

As described in Section 5.1.7.3

5.7.7.4 Instrument

As described in Section 5.1.7.4

5.7.7.5 Dataset

5.8 Instrument caveat files

5.8.1 Format:

Cluster Exchange Format as defined in reference document
DS-QMW-TN-0010, [QMW-CDF]

5.8.2 Standards:

File format: CEF-2.0
Time standard: CCSDS ASCII time standard

5.8.3 Production Procedure:

Instrument caveat files are generated as a result of the calibration and validation procedures, outlined in Sections 4.3.1 and 4.4.

5.8.4 Quality Control Procedure:

N/A

5.8.5 Delivery Procedure:

As described in section 5.1.5

5.8.6 Product Specification

Cx_CQ_FGM_CAVF__yyyymmdd_hhmmss_yyyymmdd_hhmmss_Vnn.cef
Cx refers to the spacecraft number (1, 2, 3 or 4). yyyymmdd_hhmmss indicate the start and end validity of the file. nn is the product version number.

5.8.7 Metadata Specification

5.8.7.1 Mission

As described in Section 5.1.7.1

5.8.7.2 Observatory

As described in Section 5.1.7.2

5.8.7.3 Experiment

As described in Section 5.1.7.3

5.8.7.4 Instrument

As described in Section 5.1.7.4

5.8.7.5 Dataset

```
! A unique identifier of the dataset: instrument caveat data
!
START_META     =   DATASET_ID
   ENTRY       =   "C1_CQ_FGM_CAVF"
END_META       =   DATASET_ID
!
! Used to distinguish the type of dataset
!
START_META     =   DATA_TYPE
   ENTRY       =   "CQ "
END_META       =   DATA_TYPE
!
! Short title for the dataset
!
START_META     =   DATASET_TITLE
   ENTRY       =   "Magnetic field, instrument caveats"
END_META       =   DATASET_TITLE
!
! Short description of the data product
!
START_META     =   DATASET_DESCRIPTION
   ENTRY       =   "This dataset contains caveats for magnetic field vector
data from the FGM "
   ENTRY       =   "experiment on the Cluster C1 spacecraft"
```

```
END_META        =   DATASET_DESCRIPTION
!
```

These are metadata entries for the instrument caveats from FGM1 on Cluster 1. FGM2, 3 and 4 have data entries of the same format, with the appropriate spacecraft number.

```
! Name of dataset contact
!
START_META      =   CONTACT_COORDINATES
   ENTRY        =   "Chris Carr>PI>c.m.carr@imperial.ac.uk"
END_META        =   CONTACT_COORDINATES
!
! Level of processing on the dataset
!
START_META      =   PROCESSING_LEVEL
   ENTRY        =   "Auxiliary"
END_META        =   PROCESSING_LEVEL
!
! Acknowledgement
!
START_META      =   ACKNOWLEDGEMENT
   ENTRY        =   "Please acknowledge the FGM team and ESA Cluster Active
Archive in any publication based upon use of this data"
   ENTRY        =   https://doi.org/10.5270/esa-hxcrsz5
END_META        =   ACKNOWLEDGEMENT
!
! Logical file ID for this instance of the file
!
START_META      =   LOGICAL_FILE_ID
   ENTRY        =   "C1_CQ_FGM_CAVF__20100110_134333_20100112_195917_V01"
END_META        =   LOGICAL_FILE_ID

! Version identifier for this instance of the data
!
START_META      =   VERSION_NUMBER
   ENTRY        =   "01"
END_META        =   VERSION_NUMBER
!
```

The version number might change from V01.

```
!
! Version identifier for this instance of the data
!
START_META      =   DATASET_VERSION
   ENTRY        =   "01"
END_META        =   DATASET_VERSION
!
! File format
!
START_META      =   FILE_TYPE
   ENTRY        =   "CEF"
END_META        =   FILE_TYPE
!
! Metadata specification used for this file
!
START_META      =   METADATA_TYPE
   ENTRY        =   "CAA"
END_META        =   METADATA_TYPE
!
! Version identifier for the metadata specification
```

```
!
START_META      =   METADATA_VERSION
   ENTRY        =   "2_0"
END_META        =   METADATA_VERSION
!
! Time span covered by this file
!
START_META      =   FILE_TIME_SPAN
   VALUE_TYPE   =   ISO_TIME_RANGE
   ENTRY        =   2010-01-10T13:43:33Z/2010-01-12T19:59:17Z
END_META        =   FILE_TIME_SPAN
!
! Date when the file was created
!
START_META      =   GENERATION_DATE
   VALUE_TYPE   =   ISO_TIME
   ENTRY        =   2004-11-19T09:10:16Z
END_META        =   GENERATION_DATE
!
!
! Date when the file was ingested into CAA system
!
! Caveats or dataset ID containing file caveats
!
START_META      =   FILE_CAVEATS
   ENTRY        =   ""
END_META        =   FILE_CAVEATS
!
!
```

5.8.7.6 Parameter

Each file contains the following parameters:

```
Caveat_Validity__C1_CQ_FGM
Caveat_String__C1_CQ_FGM
```

The data files for C2, 3 and 4 have similar variable names with C1 replaced by the appropriate spacecraft number.

```
START_VARIABLE  =  Caveat_Validity__C1_CQ_FGM_CAVF
    !
    ! Parameter ID
    !
    ! Type of parameter
    PARAMETER_TYPE       = "Support_Data"
    !
    ! Short description of the parameters
    CATDESC              = "Interval to which caveat applies"
    !
    ! The units of the parameter
    UNITS                = "s"
    !
    ! Ratio of data unit to SI unit (see section 6.8 of MDD)
    SI_CONVERSION        = "1.0>s"
    !
    ! Number of elements in each dimension
    SIZES                = 1
    !
```

```
    ! Type of value (may be used to assist conversion from ASCII to binary)
    VALUE_TYPE           = ISO_TIME_RANGE
    !
    ! Number of decimal digits required to preserve precision of parameter
    SIGNIFICANT_DIGITS   = 49
    !
    ! Fill value used when data value is bad or missing
    FILLVAL              = 9999-12-31T23:59:59Z/9999-12-31T23:59:59Z
    !
    ! Label discriminating the parameter (use LABELAXIS for axis)
    FIELDNAM             = "UT Time"

    !
END_VARIABLE     =  Caveat_Validity__C1_CQ_FGM_CAVF
!

START_VARIABLE  =  Caveat_String__C1_CQ_FGM_CAVF
    !
    ! Parameter ID
    !
    ! Type of parameter
    PARAMETER_TYPE       = "Support_Data"
    !
    ! Short description of the parameters
    CATDESC              = " String containing caveat information"
    !
    !
    ! Type of value (may be used to assist conversion from ASCII to binary)
    VALUE_TYPE           = CHAR
    !
    !
    ! Fill value used when data value is bad or missing
    FILLVAL              = ""
    !
!
    ! Label discriminating the parameter (use LABELAXIS for axis)
    FIELDNAM             = "Caveat"
END_VARIABLE     =  Caveat_String__C1_CQ_FGM_CAVF
!
```

5.9 Data gap files

5.9.1 Format:

Cluster Exchange Format as defined in reference document
DS-QMW-TN-0010, [QMW-CDF]

5.9.2 Standards:

File format: CEF-2.0
Time standard: CCSDS ASCII time standard

5.9.3 Production Procedure:

Pre-generated product, derived from the output of the FGM data processing software, which defines intervals of data coverage. The list of data gaps will include all gaps arising from data missing from the telemetry stream, plus any gaps introduced by the data processing software which removes bad vectors arising from several sources, as described in the data processing documentation.

5.9.4 Quality Control Procedure:

This data product is generated as part of the validation procedure, described in the FGM User Guide (CAA-EST-UG-FGM), and based on visual inspection of 5 vectors/second averaged data.

5.9.5 Delivery Procedure:

As described in section 5.1.5

5.9.6 Product Specification

Cx_CQ_FGM_GAPF__yyyymmdd_hhmmss_yyyymmdd_hhmmss_Vnn.cef

Cx refers to the spacecraft number (1, 2, 3 or 4). yyyymmdd_hhmmss indicate the start and end validity of the file. nn is the product version number.

5.9.7 Metadata Specification

5.9.7.1 Mission

As described in Section 5.1.7.1

5.9.7.2 Observatory

As described in Section 5.1.7.2

5.9.7.3 Experiment

As described in Section 5.1.7.3

5.9.7.4 Instrument

As described in Section 5.1.7.4

5.9.7.5 Dataset

```
! A unique identifier of the dataset: gaps in FGM all data sets
!
START_META     =   DATASET_ID
   ENTRY       =   "C1_CQ_FGM_GAPF"
END_META       =   DATASET_ID
!
! Used to distinguish the type of dataset
!
START_META     =   DATA_TYPE
   ENTRY       =   "CQ"
END_META       =   DATA_TYPE
!
! Short title for the dataset
!
START_META     =   DATASET_TITLE
   ENTRY       =   "Magnetic field data missing from processed data set"
END_META       =   DATASET_TITLE
!
! Short description of the data product
!
START_META     =   DATASET_DESCRIPTION
   ENTRY       =   "This dataset contains start and end times of intervals
of magnetic field data missing from all"
   ENTRY       =   "Cluster C1 data sets after the data processing stage,
but before validation"
END_META       =   DATASET_DESCRIPTION
```

!

These are metadata entries for the data gaps present in data from FGM1 on Cluster 1 after the raw data have been processed, but before the validation procedure. Gaps can arise from no data being telemetered from the spacecraft, or from bad data being removed by the data processing software. The origin of each data gap is not logged. FGM2, 3 and 4 have data entries of the same format, with the appropriate spacecraft number.

```
! Name of dataset contact
!
START_META      =    CONTACT_COORDINATES
   ENTRY        =    "Chris Carr>PI>c.m.carr@imperial.ac.uk"
END_META        =    CONTACT_COORDINATES
!
! Level of processing on the dataset
!
START_META      =    PROCESSING_LEVEL
   ENTRY        =    "Auxiliary"
END_META        =    PROCESSING_LEVEL
!
! Acknowledgement
!
START_META      =    ACKNOWLEDGEMENT
   ENTRY        =    "Please acknowledge the FGM team and ESA Cluster Active
Archive in any publication based upon use of this data"
   ENTRY        =    https://doi.org/10.5270/esa-hxcrsz5
END_META        =    ACKNOWLEDGEMENT
!
! Logical file ID for this instance of the file
!
START_META      =    LOGICAL_FILE_ID
   ENTRY        =    "C1_CQ_FGM_GAPF__yyyymmdd_hhmmss_yyyymmdd_hhmmss"
END_META        =    LOGICAL_FILE_ID
!
```

The time coverage of the file is defined in the filename. The LOGICAL_FILE_ID metadata entry for FGM2, 3 and 4 have data entries of the same format with the appropriate spacecraft number.

```
! Version identifier for this instance of the data
!
START_META      =    VERSION_NUMBER
   ENTRY        =    "01"
END_META        =    VERSION_NUMBER
!
```

The version number might change from version 1.

```
!
! Version identifier for this instance of the data
!
START_META      =    DATASET_VERSION
   ENTRY        =    "01"
END_META        =    DATASET_VERSION
!
! File format
!
START_META      =    FILE_TYPE
   ENTRY        =    "CEF"
END_META        =    FILE_TYPE
!
! Metadata specification used for this file
!
```

```
START_META     =   METADATA_TYPE
   ENTRY       =   "CAA"
END_META       =   METADATA_TYPE
!
! Version identifier for the metadata specification
!
START_META     =   METADATA_VERSION
   ENTRY       =   "2_0"
END_META       =   METADATA_VERSION
!
! Time span covered by this file
!
START_META     =   FILE_TIME_SPAN
   VALUE_TYPE  =   ISO_TIME_RANGE
   ENTRY       =   2004-01-01T00:00:00Z/2004-01-01T23:59:59Z
END_META       =   FILE_TIME_SPAN
!
! Date when the file was created
!
START_META     =   GENERATION_DATE
   VALUE_TYPE  =   ISO_TIME
   ENTRY       =   2004-11-19T09:10:16Z
END_META       =   GENERATION_DATE
!
! Caveats or dataset ID containing file caveats
!
START_META     =   FILE_CAVEATS
   ENTRY       =   "File specific caveats will be inserted here"
END_META       =   FILE_CAVEATS
```

5.9.7.6 Parameter

Each file contains the following parameter:

```
Data_Gap__C1_CQ_FGM
```

The data files for C2, 3 and 4 have similar variable names with C1 replaced by the appropriate spacecraft number.

```
START_VARIABLE  =  Data_Gap__C1_CQ_FGM_GAPF
    !
    ! Parameter ID
    !
    ! Type of parameter
    PARAMETER_TYPE       = "Support_Data"
    !
    ! Short description of the parameters
    CATDESC              = "Data gap after data processing, but before
validation"
    !
    ! The units of the parameter
    UNITS                = "s"
    !
    ! Ratio of data unit to SI unit (see section 6.8 of MDD)
    SI_CONVERSION        = "1.0>s"
    !
    ! Number of elements in each dimension
    SIZES                = 1
    !
```

```
    ! Type of value (may be used to assist conversion from ASCII to binary)
    VALUE_TYPE          = ISO_TIME_RANGE
    !
    ! Number of decimal digits required to preserve precision of parameter
    SIGNIFICANT_DIGITS  = 49
    !
    ! Fill value used when data value is bad or missing
    FILLVAL             = 9999-12-31T23:59:59Z/9999-12-31T23:59:59Z
    !
    ! Label discriminating the parameter (use LABELAXIS for axis)
    FIELDNAM            = "UT Time"
    !
    ! Short character string used to label y-axis
    LABLAXIS            = "UT"
    !
END_VARIABLE    =  Data_Gap__C1_CQ_FGM_GAPF
```

5.10 Validation gap files

5.10.1 Format:

Cluster Exchange Format as defined in reference document
DS-QMW-TN-0010, [QMW-CDF]

5.10.2 Standards:

File format: CEF-2.0
Time standard: CCSDS ASCII time standard

5.10.3 Production Procedure:

Pre-generated product, containing data gaps introduced after the data have been processed through the validation process.

5.10.4 Quality Control Procedure:

This data product is generated as part of the validation procedure, described in the FGM User Guide (CAA-EST-UG-FGM), and based on visual inspection of 5 vectors/second averaged data.

5.10.5 Delivery Procedure:

As described in section 5.1.5

5.10.6 Product Specification

Cx_CQ_FGM_VALF__yyyymmdd_hhmmss_yyyymmdd_hhmmss_Vnn.cef

Cx refers to the spacecraft number (1, 2, 3 or 4). yyyymmdd_hhmmss indicate the start and end validity of the file. nn is the product version number.

5.10.7 Metadata Specification

5.10.7.1 Mission

As described in Section 5.1.7.1

5.10.7.2 Observatory

As described in Section 5.1.7.2

5.10.7.3 Experiment

As described in Section 5.1.7.3

5.10.7.4 Instrument

As described in Section 5.1.7.4

5.10.7.5 Dataset

```
! A unique identifier of the dataset: gaps introduced by the FGM data
! validation process
!
START_META      =   DATASET_ID
   ENTRY        =   "C1_CQ_FGM_VALF"
END_META        =   DATASET_ID
!
! Used to distinguish the type of dataset
!
START_META      =   DATA_TYPE
   ENTRY        =   "CQ"
END_META        =   DATA_TYPE
!
! Short title for the dataset
!
START_META      =   DATASET_TITLE
   ENTRY        =   "Magnetic field data removed by validation process"
END_META        =   DATASET_TITLE
!
! Short description of the data product
!
START_META      =   DATASET_DESCRIPTION
   ENTRY        =   "This dataset contains start and end times of intervals
of data removed from all"
   ENTRY        =   "data sets at the validation stage of data production
of"
   ENTRY        =   "magnetic field vectors from the FGM experiment on the
Cluster C1 spacecraft"
END_META        =   DATASET_DESCRIPTION
!
```

These are metadata entries for the data gaps introduced at the validation stage of data from FGM1 on Cluster 1. FGM2, 3 and 4 have data entries of the same format, with the appropriate spacecraft number.

```
! Name of dataset contact
!
START_META      =   CONTACT_COORDINATES
   ENTRY        =   "Chris Carr>PI>c.m.carr@imperial.ac.uk"
END_META        =   CONTACT_COORDINATES
!
! Level of processing on the dataset
!
START_META      =   PROCESSING_LEVEL
   ENTRY        =   "Auxiliary"
END_META        =   PROCESSING_LEVEL
!
! Acknowledgement
!
START_META      =   ACKNOWLEDGEMENT
   ENTRY        =   "Please acknowledge the FGM team and ESA Cluster Active
Archive in any publication based upon use of this data"
```

```
   ENTRY         =   https://doi.org/10.5270/esa-hxcrsz5
END_META         =   ACKNOWLEDGEMENT
!
! Logical file ID for this instance of the file
!
START_META       =   LOGICAL_FILE_ID
   ENTRY         =   "C1_CQ_FGM_VALF__yyyymmdd_hhmmss_yyyymmdd_hhmmss"
END_META         =   LOGICAL_FILE_ID
!
```

The time coverage of the file is defined in the filename. The LOGICAL_FILE_ID metadata entry for FGM2, 3 and 4 have data entries of the same format with the appropriate spacecraft number.

```
! Version identifier for this instance of the data
!
START_META       =   VERSION_NUMBER
   ENTRY         =   "01"
END_META         =   VERSION_NUMBER
!
```

The version number might change from version 1.

```
!
! Version identifier for this instance of the data
!
START_META       =   DATASET_VERSION
   ENTRY         =   "01"
END_META         =   DATASET_VERSION
!
! File format
!
START_META       =   FILE_TYPE
   ENTRY         =   "CEF"
END_META         =   FILE_TYPE
!
! Metadata specification used for this file
!
START_META       =   METADATA_TYPE
   ENTRY         =   "CAA"
END_META         =   METADATA_TYPE
!
! Version identifier for the metadata specification
!
START_META       =   METADATA_VERSION
   ENTRY         =   "2_0"
END_META         =   METADATA_VERSION
!
! Time span covered by this file
!
START_META       =   FILE_TIME_SPAN
   VALUE_TYPE    =   ISO_TIME_RANGE
   ENTRY         =   2004-01-01T00:00:00Z/2004-01-01T23:59:59Z
END_META         =   FILE_TIME_SPAN
!
! Date when the file was created
!
START_META       =   GENERATION_DATE
   VALUE_TYPE    =   ISO_TIME
   ENTRY         =   2004-11-19T09:10:16Z
END_META         =   GENERATION_DATE
!
```

```
! Caveats or dataset ID containing file caveats
!
START_META     =   FILE_CAVEATS
   ENTRY       =   "File specific caveats will be inserted here"
END_META       =   FILE_CAVEATS
```

5.10.7.6 Parameter

Each file contains the following parameter:

```
Validation_Gap__C1_CQ_FGM
```

The data files for C2, 3 and 4 have similar variable names with C1 replaced by the appropriate spacecraft number.

```
START_VARIABLE  =  Validation_Gap__C1_CQ_FGM_VALF
    !
    ! Parameter ID
    !
    ! Type of parameter
    PARAMETER_TYPE      = "Support_Data"
    !
    ! Short description of the parameters
    CATDESC             = "Data gap defined by validation process"
    !
    ! The units of the parameter
    UNITS               = "s"
    !
    ! Ratio of data unit to SI unit (see section 6.8 of MDD)
    SI_CONVERSION       = "1.0>s"
    !
    ! Number of elements in each dimension
    SIZES               = 1
    !
    ! Type of value (may be used to assist conversion from ASCII to binary)
    VALUE_TYPE          = ISO_TIME_RANGE
    !
    ! Number of decimal digits required to preserve precision of parameter
    SIGNIFICANT_DIGITS  = 49
    !
    ! Fill value used when data value is bad or missing
    FILLVAL             = 9999-12-31T23:59:59Z/9999-12-31T23:59:59Z
    !
    ! Label discriminating the parameter (use LABELAXIS for axis)
    FIELDNAM            = "UT Time"
    !
    ! Short character string used to label y-axis
    LABLAXIS            = "UT"
    !
END_VARIABLE    =  Validation_Gap__C1_CQ_FGM_VALF
```

5.11 Documentation

5.11.1 Format:

All documentation is provided in PDF format

5.11.2 Standards:

N/A

5.11.3 Production Procedure:

N/A

5.11.4 Quality Control Procedure:

The documents are reviewed before submission.

5.11.5 Delivery Procedure:

The documentation is submitted via email.

5.11.6 Product Specification

CL_CD_FGM_DOCS_xx.pdf

5.11.7 Metadata Specification

5.11.7.1 Mission

As described in Section 5.1.7.1

5.11.7.2 Observatory

As described in Section 5.1.7.2

5.11.7.3 Experiment

As described in Section 5.1.7.3