Space Research Institute
Dep. for experimental space research
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VENUS EXPRESS MAGNETOMETER

To Planetary Science Archive Interface Control Document

VE-MAG-EAICD

Version 1.4

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Distribution List

Recipient	Organisation	Recipient

Change Log

Date	Sections Changed	Reasons for Change
14. Dec. 2006	all	First issue
18. Oct. 2007	§ 3.1.1 Deliveries and Archive Volume Format	Directory SOFTWARE added
May 2008	All	According to VE-EST-RID-MAG from first peer review, 2008-03
23 Sept. 2008	§ 2.2.4 Operation and Data Sampling § 2.5.3 In-Flight Data Products § 3.1 Format and Conventions § 4.2 Data Sets, Definition and Content	CODMAC2 in nT; higher data-rates added
20. Jan 2009	§2.5.3.2 §4.2.3 Data contents § Appendix I	Description of RAW data modified
22. Sept. 2009	Appendix II and III	Correction of data-coordinate systems

TBD ITEMS

Section	Description

Table Of Contents

1 Introduction

1.1 Purpose and Scope

The purpose of this EAICD (Experimenter to (Science) Archive Interface Control Document) is two fold. First it provides users of the MAG magnetometer instrument with detailed description of the product and a description of how it was generated, including data sources and destinations. Secondly, it is the official interface between MAG magnetometer and ESA's Planetary Science Archive.

1.2 Archiving Authorities

The Planetary Data System Standard is used as archiving standard by

- NASA for U.S. planetary missions, implemented by PDS
- ESA for European planetary missions, implemented by the Research and Scientific Support Department (RSSD) of ESA

1.2.1 ESA's Planetary Science Archive (PSA)

ESA implements an online science archive, the PSA,

- to support and ease data ingestion
- to offer additional services to the scientific user community and science operations teams as e.g.
    - search queries that allow searches across instruments, missions and scientific disciplines
    - several data delivery options as
        - direct download of data products, linked files and data sets
        - ftp download of data products, linked files and data sets

The PSA aims for online ingestion of logical archive volumes and will offer the creation of physical archive volumes on request.

1.3 Contents

This document describes the data flow of the MAG instrument on the Venus Express mission from the S/C until the insertion into the PSA for ESA. It includes information on how data were processed, formatted, labeled and uniquely identified. The document discusses general naming schemes for data volumes, data sets, data and label files. Standards used to generate the product are explained. Software that may be used to access the product is explained further on.

The design of the data set structure and the data product is given. Examples of these are given in the appendix.

1.4 Intended Readership

The staff of the archiving authority (Planetary Science Archive, ESA, RSSD, design team) and any potential user of the MAG magnetometer data.

1.5 Scientific Objectives

The magnetometer aboard Venus Express (MAG) will conduct the following studies:

- Provide the magnetic field data for any combined field, particle and wave studies such as lightning and planetary ion pickup processes;
- Map with high time resolution the magnetic properties in the magnetosheath, magnetic barrier, the ionosphere, and the magnetotail. Identify the plasma boundaries between the various plasma regions.
- Study of the solar wind interaction with the Venus atmosphere

1.6 Applicable Documents

General PDS documents

Planetary Data System Preparation Workbook,
February 1, 1995, Version 3.1, JPL, D-7669, Part1
Planetary Data System Standards Reference,
June 1, 1999, Version 3.3, JPL, D-7669, Part 2

Specific Venus Express and MAG instrument documents

Document description	Document reference
Venus Express Archive Generation, Validation and Transfer Plan, in the current version	VEX-RSSD-PL-001
VEX MAG instrument description	ZHANGAL-MAG-ESA-SP1295
VEX MAG science data processing description, in the current version (IWF)	VE-MAG-SCIENCE-DATA-PROCESSING-DESCRIPTION

1.7 Relationships to Other Interfaces

None

1.8 Acronyms and Abbreviations

PSA	Planetary Science Archive
MAG	Venus Express magnetometer
VEX	Venus Express
IWF	Space Research Institute, Graz, Austria
IC	Imperial College, London, UK
IGeP	Institut für Geophysik und extraterrestrische Physik, TU Braunschweig, BRD
EAICD	Experimenter to (Science) Archive Interface Control Document
ESA	European Space Agency
RSSD	Research and Scientific Support Department of ESA
S/C	Spacecraft
ASCII	American Standard Code for Information Interchange
UTC	Coordinated Universal Time
B	Magnetic Field
IS	Inboard Sensor
OS	Outboard Sensor
QF	Quality Flag
SW	Software

1.9 Contact Names and Addresses

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2 Overview of Instrument Design, Data Handling Process and Product Generation

2.1 Science Background

Venus, like other planets in the solar system, is under the influence of a continuous flow of charged particles from the Sun, the solar wind. Lacking an intrinsic magnetic field makes Venus a unique object for studying the interaction between the solar wind and the planetary body. The planetary body has a dense atmosphere, but no magnetic field, thus the solar wind interacts directly with the upper atmosphere. The highly electrically conductive ionosphere deflects the oncoming supersonic solar wind around the planet so that a bow shock is formed. The interaction of post-shock solar wind flow and the ionosphere also results in a distinct boundary, the so-called ionopause. This ionopause separates the thermal plasma of the ionosphere from the hot magnetized plasma of the magnetosheath which is defined as the region between the ionopause and the bow shock.

The absence of a planetary magnetic field leads to important differences between Venus' and Earth's atmospheric escape and energy deposition processes. The upper atmosphere of Venus is not protected by the magnetic field from direct interaction with the solar wind. As a result, a large portion of the exosphere resides in the shocked solar wind flow; the photo ionisation, charge exchange and electron impact ionisation effectively remove ionised exospheric components by the plasma flow. The tailward convection of the plasma mantle, situated between the shocked solar wind flow and the ionosphere, leads to another type of atmospheric loss. The ions gyrating around the magnetic field embedded in plasma may re-enter the atmosphere causing its massive sputtering.

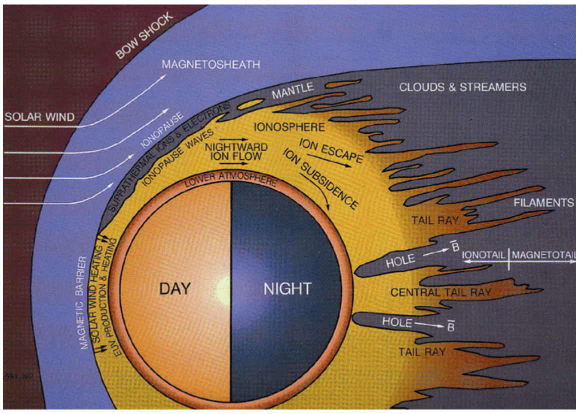

Fig. 1 Venus plasma environments

Finally, erosion of the Venusian ionosphere under varying solar wind conditions provides an additional loss mechanism for atmospheric constituents. The solar wind interacts with the top of the ionosphere to form a complex array of plasma clouds, tail rails, filaments and ionospheric holes on the night side through those a substantial amount of material leaves the planet. Figure 1 illustrates associated electrodynamics processes and plasma domains of the Venus upper ionosphere.
The earlier missions, Venera and Pioneer orbiters found that the current induced by the solar wind electric field forms a magnetic barrier that deflects the most of the solar wind flow around the planet and leads to the formation of the bow shock. The ionosphere is terminated on the dayside, developing rapid anti-sunward convection and tail rays. However, the short lifetime of the Venera-9 and -10 orbiters, and insufficient temporal resolution of the Pioneer plasma instrument did not allowed a study of the mass exchange between the solar wind and the upper atmosphere of Venus and energy deposition to the upper atmosphere in sufficient detail.

2.2 Instrument Design

2.2.1 Introduction

A short description of the instrument can be found in

MAG: The Fluxgate Magnetometer of Venus Express
Zhang, T.L. et al., 2005, ESA – SP1295.

(see DOCUMENT file: ZHANGAL-MAG-ESA-SP1295)

The VEX magnetometer MAG measures the 3D magnetic field in the frequency bandwidth from DC to 128 Hz. It consists of two triaxial fluxgate sensors (MAGOS and MAGIS). The dual sensor configuration was chosen for a better monitoring of the stray magnetic fields produced from other S/C units. The electronics box comprises two sensor electronics boards, the DPU board and the DC/DC converter.

MAGOS is mounted to the tip of a deployable boom whereas the inboard sensor (MAGIS) is directly attached to the +Z panel of the spacecraft.

Sub-unit identification as well as a basic overview of the MAG functional blocks is given in the following figure.

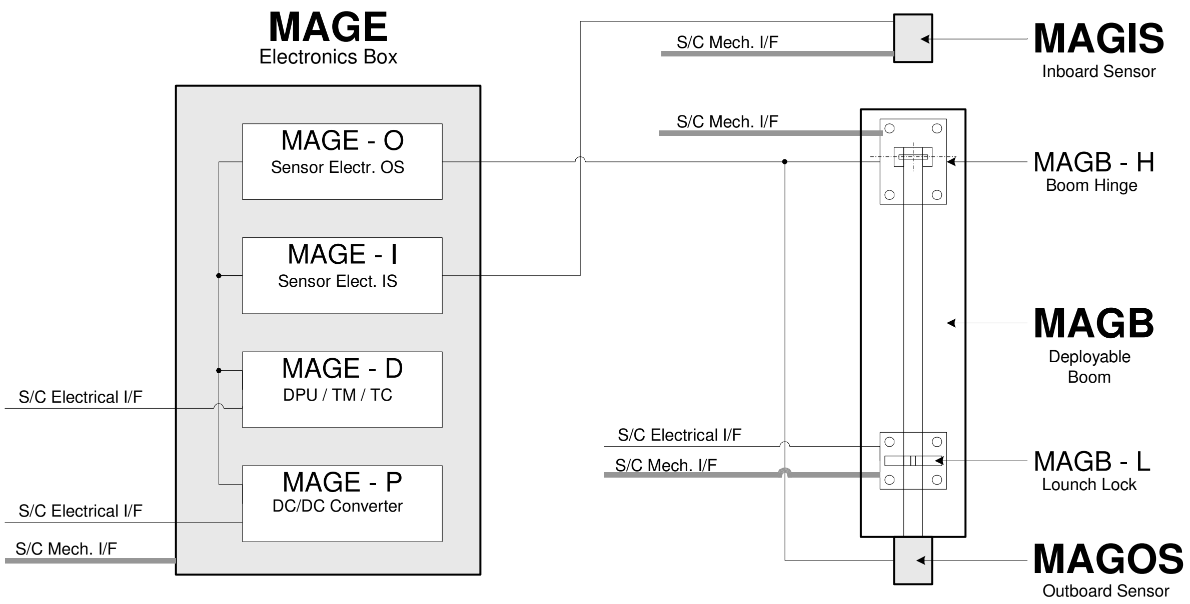

Fig. 2.2-1 Instrument hardware building blocks

2.2.2 Fluxgate Sensors

Both fluxgate sensors, featuring low mass and power consumption, consist of two single ring-core sensors measuring the magnetic field in X- and Y-direction. The magnetic field in Z-direction is measured by a coil surrounding both single sensors. The side length of the cubic shaped sensor triad is approx. 5 cm.

The sensor is identical to the ones of Rosetta Lander and MIR instrument package and similar to the ones flown on Equator-S (same soft-magnetic ringcores made of an ultra-stable 6-81 Mo permalloy band: 2 mm × 20 µm). The ringcores have been tested under extreme environmental conditions aboard numerous space missions as well as in applied geophysics. The excellent low noise and stability behaviour of the sensor material has especially been proven aboard Equator-S.

Because of the wide operating temperature range of the fluxgate sensor from –160 °C up to +120 °C, the sensor can be mounted outside of the temperature controlled S/C only covered by a passive multi-layer insulation blanket. No active heating or cooling is needed for the sensors.

The instrument performed very well during ground calibration. At 1 Hz the noise density is less than 10 pT/√Hz for a sensor temperature range from 0ºC to +90ºC (the range in orbit around Venus) and the offset stability is better than 2 nT over the sensor temperature range from –75ºC to 90ºC.

2.2.3 Sensor Position and Orientation

The following tables show the magnetic centers of the MAG sensors –deployed situation - with respect to the S/C coordinate system.

Unit	Xs [mm]	Ys [mm]	Zs [mm]
MAGIS	247	-709	1683
MAGOS	377	-510	2622
Delta: OS minus IS	130	199	939

Tab. 2-1 Magnetic centers of MAGIS/OS in S/C coordinate system (deployed)

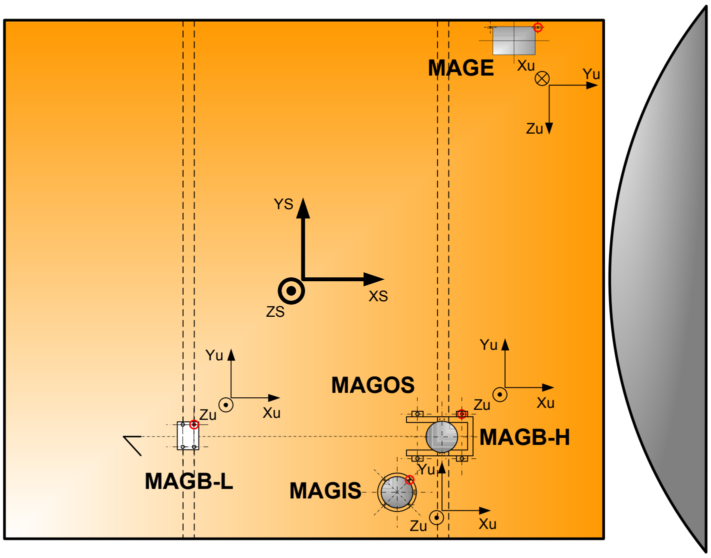

Fig. 2.2-2 Instrument axes and orientation w.r.t spacecraft axes

2.2.4 Operation and Data Sampling

MAG is based on the dual-magnetometer method to allow separation of the spacecraft stray field from the ambient space field. Therefore, both sensors always take measurements simultaneously.

2.2.4.1 The possible science modes are:

Instrument Mode	Sensors active	Data Rate transmitted to Earth
Solar wind "SW1"	OS and IS	1 Hz
Pericenter "PC1"	OS and IS	32 Hz
Burst "CAL5"	OS and IS	128 Hz

When MAG is active, data sampling onboard is always with 128 Hz data rate. For operation of the instrument in "Solar wind mode" and "Pericenter mode", the data samples are reduced by filtering methods to the required lower data rate by the onboard processor. Only for "Burst mode" the full set of data samples at 128 Hz data rate is transmitted to Earth.

After switching on, MAG automatically operates in the standard mode which is "Solar wind mode" with simultaneous 1 Hz data of both sensors transmitted to Earth.

2.2.4.2 CRUISE phase:

MAG was the first instrument to be commissioned on Venus Express, 10 days after launch, and its boom deployed. Afterwards, it remained ON during the commissioning of all the other instruments, to enable registration and characterisation of the magnetic disturbances generated during payload operation.

During the CRUISE phase, only "Solar wind mode" is default and 1 Hz data rate is transmitted.

Instrument Mode	Sensors active	Data Rate	Nominal operation in cruise phase
Solar wind "SW1"	OS and IS	1 Hz	always active

2.2.4.3 Nominal science modes in nominal orbit around Venus (= after start of "nominal mission" 14-05-2006):

MAG is operating continuously in orbit around Venus (which is in principle 24 hr per 24 hr orbit around Venus) and mostly in an autonomous mode, requiring little or no commanding. Higher data-rates are started only after start of the nominal mission in orbit around Venus (14 May 2006).

During a typical science orbit, MAG is switched to "Pericenter mode" one hour before pericenter, and then back to "Solar wind mode" one hour after pericenter.

The instrument is commanded to the high resolution "Burst mode" one minute before pericenter for duration of 2 min in order to detect lightning.

Instrument Mode	Sensors active	Data Rate	Nominal operation in nominal orbit
Solar wind "SW1"	OS and IS	1 Hz	always active, i.e. full orbit sampling coverage, except if mode with higher data rate is active
Pericenter "PC1"	OS and IS	32 Hz	1 hr before and after pericenter
Burst "CAL5"	OS and IS	128 Hz	1 min before and after pericenter

2.2.5 Data filtering onboard

Within the VEX-MAG software packet three different filter modes are implemented:

- No Filter (FilterID = 0)
- Averaging Filter (FilterID = 1)
- FIR Filter (FilterID = 2)

Using the telecommands MAGOSSetFilter and MAGISSetFilter the Filter option for each sensor can be selected.

2.2.5.1 No Filter

This filter mode shall only be used when the raw data, sampled with 128 Hz is requested. In all other cases the Nyquist–Shannon sampling theorem is not satisfy and aliasing will be produced.

If the data rate is set to 64Hz, each odd sample is transmitted while the even samples are dropped. In the case of 32Hz data rate each 4th sample is transmitted (1st, 5th, 9th...) while the other ones are dropped.

2.2.5.2 Averaging Filter

Using this filter mode the 128 Hz raw data from the sensor electronics are averaged with an overlapping box car (averaging) filter. The frequency response for different data rates are shown in Fig. 2.2-3, Fig. 2.2-4 and Fig. 2.2-5.

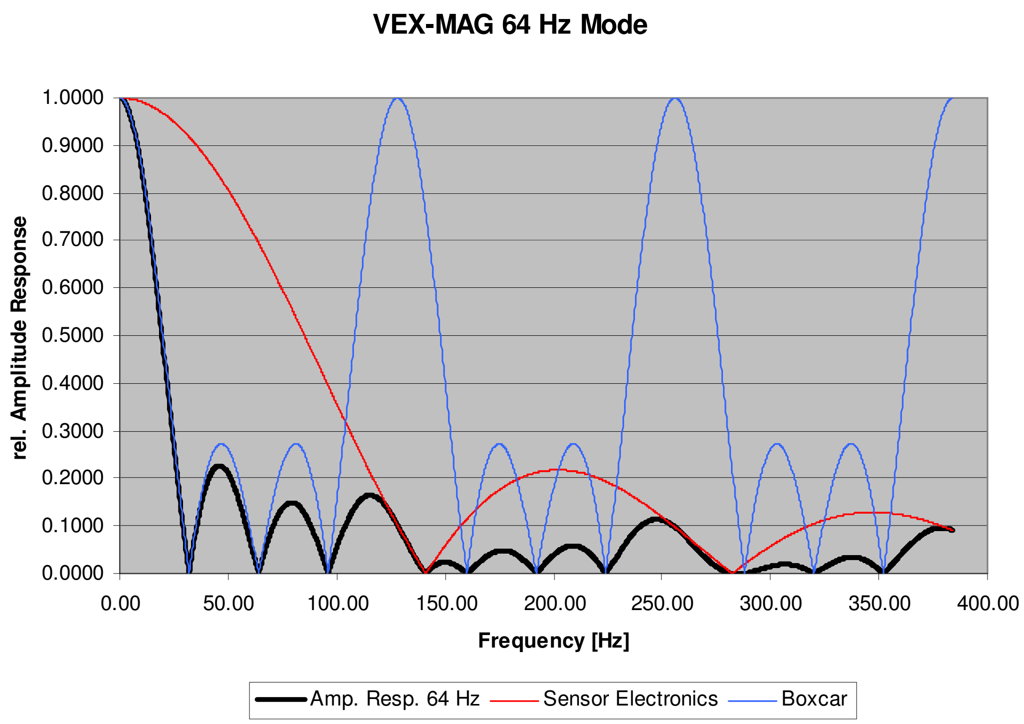

Fig. 2.2-3 Frequency response of the box car filter (data rate 64 Hz)

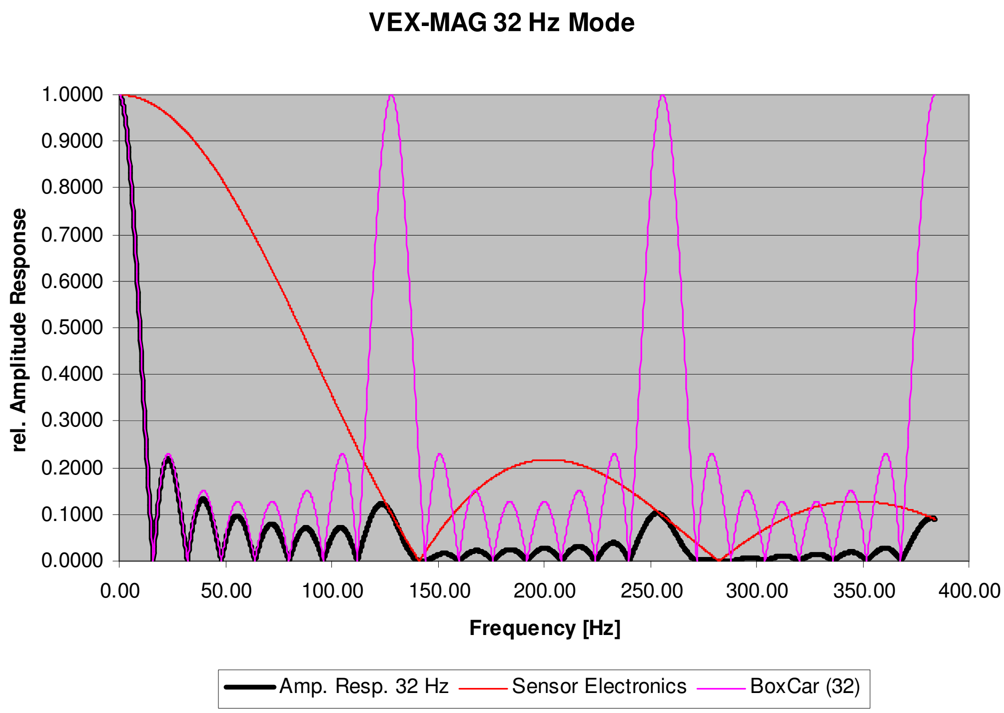

Fig. 2.2-4: Frequency response of the box car filter (data rate 32 Hz)

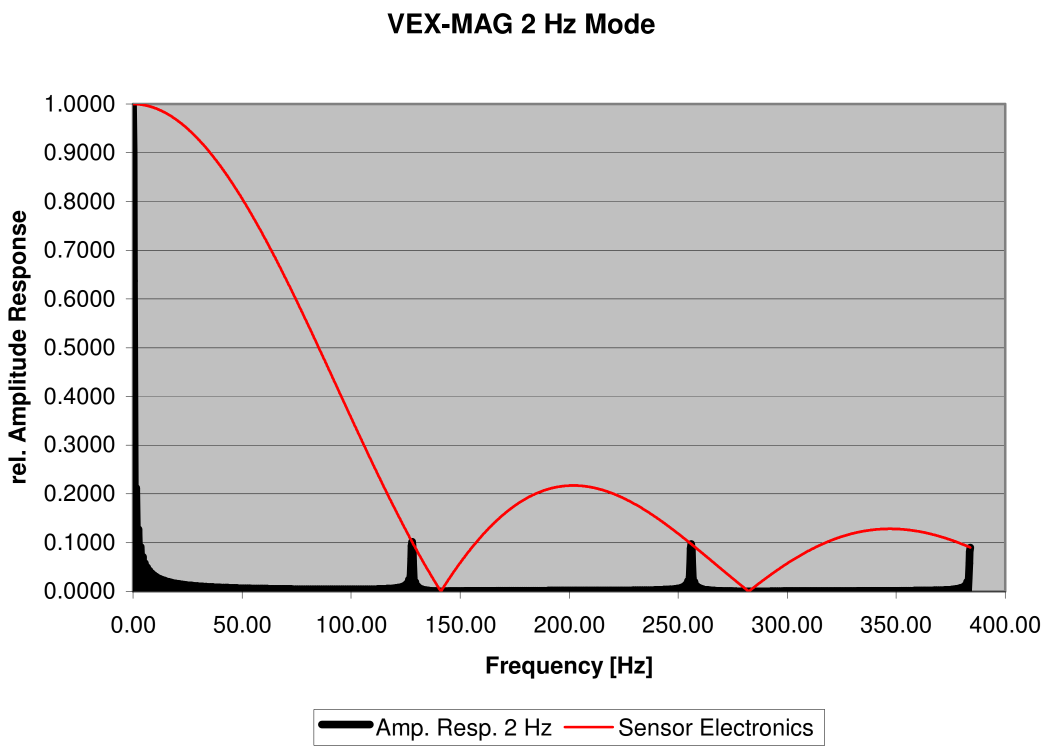

Fig. 2.2-5: Frequency response of the box car filter (data rate 2 Hz)

2.2.5.3 FIR Filter

Using this filter mode the 128 Hz raw data from the sensor electronics are averaged with a cascade of FIR half band filter 17^{th} order with Hanning characteristic. The Fig. 2.2-6 below shows the structure of the used FIR half band filter:

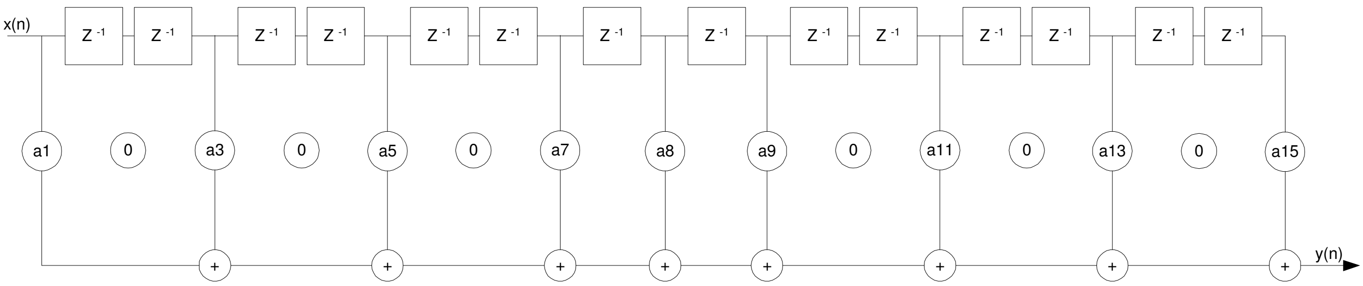

Fig. 2.2-6: FIR half band filter 17th order

The coefficients of this half band filter are given in the Table 2.2-1 :

Coefficient	Value
a0	0
a1	-0.00531893983961
a2	0
a3	0.02629639672517
a4	0
a5	-0.07956381221274
a6	0
a7	0.30864305659745
a8	0.49988659745946
a9	0.30864305659745
a10	0
a11	-0.07956381221274
a12	0
a13	0.02629639672517
a14	0
a15	-0.00531893983961
a16	0

Table 2.2-1: Coefficients of the used 17th order FIR half band filter

The complete filter bank is composed of a cascade of seven stages of the previous described FIR half band filter to achieve the decimation from 128Hz input data to 1Hz output data. The frequency response for different data rates are shown in Fig. 2.2-8 and Fig. 2.2-9.

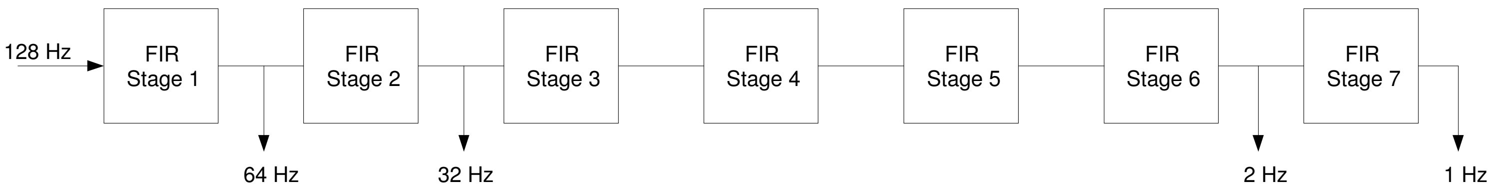

Fig: 2.2-7 Cascade of seven FIR half band filters

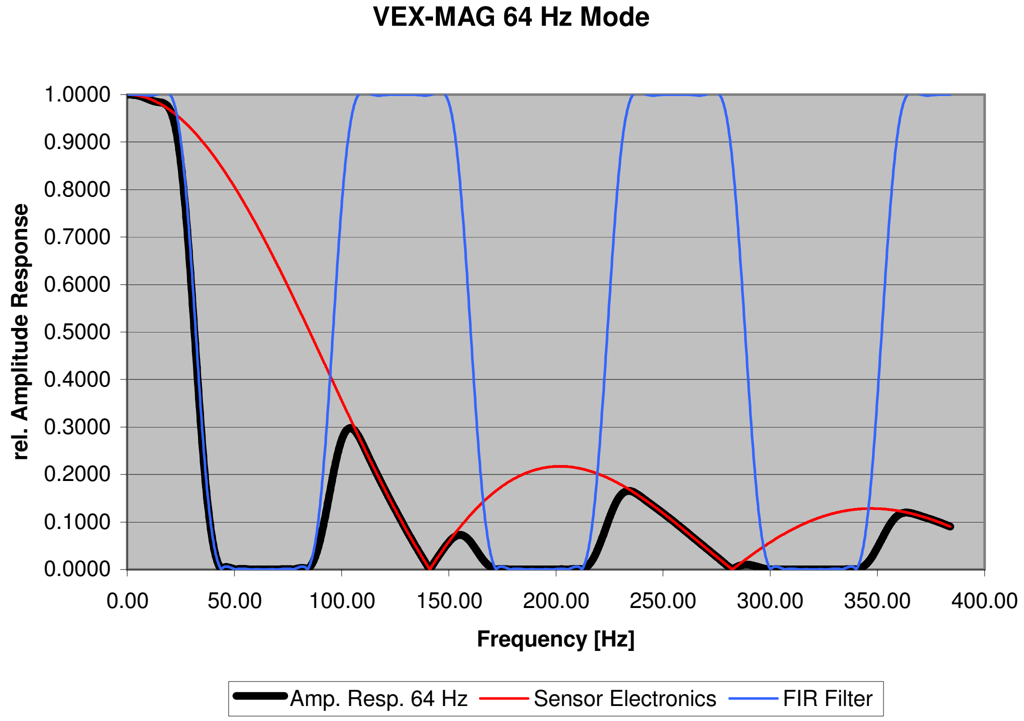

Fig. 2.2-8: Frequency response of the FIR filter (data rate 64 Hz)

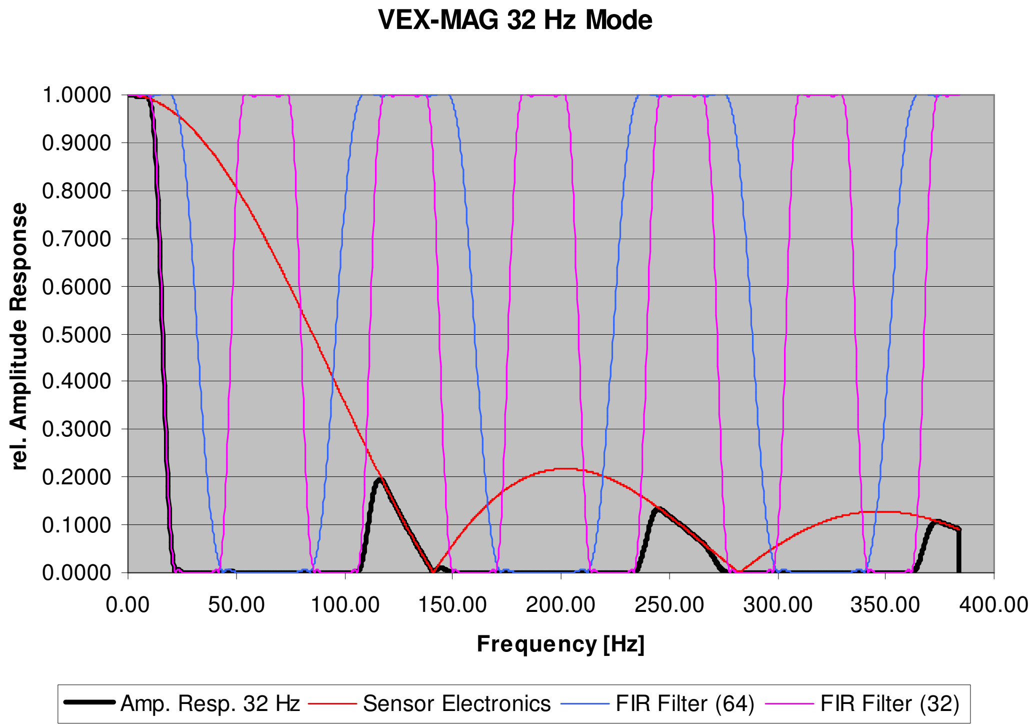

Fig. 2.2-9: Frequency response of the FIR filter (data rate 32 Hz)

2.2.5.4 Applied filter to the in-flight 1Hz data

For the 1 Hz data in-flight (and later also on ground) only the **FIR** filter was used.

2.3 Data Handling Process

2.3.1 Overview

Data processing is executed in several steps and with various methods.

Processing of the data received from the spacecraft to obtain RAW data:

- Correction of spacecraft received data for known sensor effects
- Synchronisation of the two sensor data-sets

From RAW to CALIBRATED data:

- Raw-data correction for variable S/C stray field effects (neural networks, fuzzy logics, model fitting)
- Raw-data correction for secular S/C stray field effects (Solar Wind methods)
- The calibration procedure on the measurements of the two sensors yields the space magnetic field vector as result, in spacecraft coordinates

From CALIBRATED to RESAMPLED data:

Here mainly averaging methods are used.

2.3.2 Data correction for sensor & filtering effects, synchronisation to get RAW data (CODMAC level 2)

This part of the data-correction is an INTERNAL pipeline done at IWF-Graz and described in the IWF-INTERNAL document in the current version:

VE-MAG-SCIENCE-DATA-PROCESSING-DESCRIPTION

2.3.3 RAW to CALIBRATED: correction for spacecraft stray field effects

The measurements during flight are the sum of the ambient space field and stray fields from the spacecraft, with the space field the same at both sensors. When the magnetometers are well-calibrated, i.e. they perform identically, then any difference is attributable to the spacecraft. If a single source is identified at a known position on the spacecraft, a model dipole field can be determined from the dual magnetometer measurement and subtracted to obtain the ambient space field. From this initial state, any change in the spacecraft effects is indicated by a change in the difference between the measurements at both sensors. In principle, identification of the disturbing source (and its temporal changes) from the in-flight telemetry enables a correction of the data for the stray field effects. Optimally, the corresponding model dipoles known from the ground survey can be used. However, the Venus Express stray field effects are much more complicated and of a multi-dipole nature, so a combination of different methods is used. In the solar wind, well-known statistical methods, using time series of solar wind measurements, are used to determine an initial ambient space field level from the measurements at both sensors, with the data-difference only due to some initial state of the spacecraft effects. Temporal variations from this initial state are detected and, if possible, allotted to a single source on the spacecraft to allow correction.
For Venus Express, routine manual identification of stray field patterns and their sources (known from the magnetic survey) and subsequent correction are beyond the resources of the MAG team. This raises the need for an automated correction procedure.
Since 2003, a new method of combining dual magnetometry and high performance computation using neural networks has been under consideration. A neural network pattern-recognition algorithm was developed to identify stray field patterns in the differences of the magnetic field measurements at the sensors.

A test algorithm was applied to simulated measurement data (ambient field and disturbance from up to seven simultaneous model dipoles), producing satisfactory results. The algorithm was successfully tested on real magnetic field measurements from Double Star. MAG data from the commissioning of the other instruments and the cruise data provided a 'learning sequence" for the neural network algorithm. For the science data at Venus, a combination of the automated neural network algorithm and, in the worst case, correction by human resources is being applied.

2.4 Product Generation

The available data-sets at IWF are transformed by the IWF archiving team to the required PDS structure.

2.5 Overview of Data Products

2.5.1 Pre-Flight Data Products

NO pre-flight products are included in the archive.

2.5.2 Instrument Calibrations

NO calibration functions are included in the archive.

Information about the calibration and details is stored at IWF.

2.5.3 In-Flight Data Products

In-flight data products are restricted to the measured data only.

2.5.3.1 Housekeeping data (HK)

NO HK data (temperatures, voltages) are injected into the archive, since they are NOT used for calibration. They are stored at IWF and are used for monitoring the health of the instrument. Since this is in perfect order, NO HK data were used for calibration.

2.5.3.2 Measurement data

The following types of data are in the archive:

RAW SENSOR DATA
= data in nano Tesla, CODMAC level 2:

Raw, synchronized sensor data

Data from the two sensors MAG-IS, MAG-OS in S/C coordinates, synchronized, in nano Tesla [nT].

Data are corrected for known sensor-effects; at certain times the data from both sensors still consist of a significant amount of variable spacecraft background field; the ratio of the background spacecraft field at the sensors is variable in time.

Data of this type are available for different data resolutions: 1 Hz, 32 Hz, 128 Hz.

WARNING:
Due to the variability of the spacecraft field in the RAW sensor data, these data should be used with caution and in collaboration with the MAG-team.

CALIBRATED DATA

= Space magnetic field data, in physical units, CODMAC level 3:

Space magnetic field data in physically meaningful coordinates (HSE;VSO) in nanoTesla; position of S/C in meaningful coordinate system

Data of this type are available only for data resolution of 1 Hz.

RESAMPLED CALIBRATED DATA

= Averaged space magnetic field data, in physical units, CODMAC level 4:

Space magnetic field data in physically meaningful coordinates (HSE, VSO) in nanoTesla; averaged from space magnetic field data; position of S/C in meaningful coordinate system

Data of this type are available with data resolution lower than 1Hz.

Definition of the coordinate systems is given in § 3.2.3 Reference Systems.

IMPORTANT NOTES:

- In-flight data products of 1 Hz data-resolution i.e. "Solar wind mode" data provide nearly full data-coverage for all times of the spacecraft in orbit around Venus. All data intervals of higher data rate are down-sampled with the same methods as onboard (see § 2.2.4) and merged into the 1 Hz data set, to enable a full coverage with equidistant samples in time.

  So 1 Hz data are available for the whole mission duration (after Venus orbit insertion, 12 April 2006) and nearly without data-gaps, since MAG is ON in principle at ALL times.

- CODMAC LEVEL 2 data, i.e. RAW SENSOR DATA, are available in the archive on a regular basis for the data rates 1Hz, 32 Hz and 128 Hz.

- CODMAC 3 and CODMAC 4 data-levels will be provided only as processed from the 1 Hz raw data-set.
  No CODMAC 3 nor CODMAC 4 data-levels for data-resolutions other than 1 Hz are foreseen.

2.5.4 Software

The data processing software is available at IWF-Graz, but NOT available in the archive, since there is no single straight-forward pipeline; data are run through several single packages by various groups.

These data-processing steps cannot be performed in a straight forward way and, therefore, no software is delivered.

2.5.5 Ancillary Data Usage

MAG uses orbit, attitude, orbit number data from ESOC within the data processing chain, to produce data in a physically meaningful coordinate system.

3 Archive Format and Content

3.1 Format and Conventions

3.1.1 Deliveries and Archive Volume Format

Each MAG archive data-set has the following structure, where one volume is one data-set, i.e. volume and data-set are identical.

```
DATASET_ID
        |--- CATALOG
        |--- DATA
        |--- DOCUMENT
        |--- INDEX
```

3.1.2 Data Set ID Formation

The maximum length of the DATA_SET_ID is 40 characters. Multiple targets will be referenced by concatenation of the values with a "/", which is interpreted as "and" and is formatted like this:

```
DATA_SET_ID = "<INSTRUMENT_HOST_ID> - <target id> - <INSTRUMENT_ID>-
<data processing level number> - <version>"
```

For example:

```
1234567890123456789012345678901234567
VEX-V/Y-MAG-2-V1.0
```

where:

Element	Value	Status
<INSTRUMENT_HOST_ID>	VEX	req
<target id>	V/Y	req
<INSTRUMENT_ID>	MAG	req
<data processing level number>	CODMAC level 2,3,4	req
<version>	e.g. V1.0	req

Table 1 Elements for the DATA_SET_ID formation.

TARGET_NAME	TARGET_TYPE	<target name> in DATA_SET_NAME	<target id> in DATA_SET_ID
“VENUS”	“PLANET”	VENUS	V
"EARTH"	"PLANET"	EARTH	E
"MARS"	"PLANET"	MARS	M
"CALIBRATION"	"CALIBRATION"	CAL	CAL
"CHECKOUT"	"N/A"	CHECK	X
"SOLAR WIND"	"SOLAR SYSTEM"	SW	Y

Table 2 Standard values related to targets.

3.1.3 Data Directory Naming Convention

In the DATA-directory, data are archived according to different phases from the flight before the Venus Orbit Insertion.

After Venus orbit injection, data directories are archived according to DATA PHASE NAME, which is according to DATE and not according to orbit numbers.
Therefore, all DATA-directory-names contain a " DATA PHASE NAME", as defined in Table 3, and an indication of the data- or time-resolution of the data.

No directory name is longer than 32 characters and the data directory has the following structure:

```
|--- DATA
        |--- XXXXXXXXX_ZZZZ
                  Filename1 per DOY
                  Filename2 per DOY
                  Etc.
        |--- XXXXXXXXX_ZZZZ
```

where:
XXXXXXXXX : data phase name ID
ZZZZ : denotes the **data-rate or resolution** of the data in the files.
DZZZ : denotes the DATA-rate of the data in the file for the products
RAW_SENSOR_DATA
CALIBRATED_DATA
values are according to the sheme:
D001 for 1 Hz data-rate
D032 for 32 Hz data-rate (only for CODMAC 2)
D128 for 128 Hz data-rate (only for CODMAC 2)
RZZZ : denotes the DATA-rate in the file for the product
RESAMPLED_CALIBRATED_DATA
values are according to the sheme:
SZZZ (Resolution in ZZZ Seconds)
MZZZ (Resolution in ZZZ Minutes)
HZZZ (Resolution in ZZZ Hours)

DATA_PHASE_NAME	**DATA_PHASE_NAME_ID in DATA-Directory-names**
	"XXXXXXXXX"
"Commissioning at Earth"	"COMMEARTH"
"Cruise Phase year month"	"CRU200601"
	"CRU200602"
	"CRU200603"
"Capture Orbit at Venus"	"CAPTORBIT"
"Commissioning at Venus"	"COMMVENUS"
"Orbit at Venus year month"	"ORB200605"
	"ORB200606"
Etc . . .	

Table 3 Data Phase name descriptions

3.1.4 File-naming Convention

This is the MAG file-naming convention for the data-files in the DATA –sub-directories.
File-names are NOT longer than 31 digits, ie. name(<=27).ext(3) (PDS standard).
All data are archived in ASCII-files.

- **Data Product RAW_SENSOR_DATA :**
  = Raw synchronized sensor data, CODMAC Level 2:

```
Position: 1234567890123456789012345678.123
```

```
Filename: BIO_YYYYMMDD_DOYXXX_DZZZ_VN.TAB
where
     YYYYMMDD     : date
     XXX          : day of the year
     DZZZ         : denotes the DATA-rate of the data in the file, where D is
                    used for original data-rate files from the S/C;
                    values are according to the sheme:
                                D001   for   1 Hz data-rate
                                D032   for  32 Hz data-rate (only for CODMAC 2)
                                D128   for 128 Hz data-rate (only for CODMAC 2)
     N            : Version number
Example:
     BIO_20061115_DOY319_D001_V1.TAB
```

- **Data Product CALIBRATED data:**
  = Space magnetic field data, CODMAC Level 3:

```
Position: 12345678901234567890123456 7.123
Filename: MAG_YYYYMMDD_DOYXXX_DZZZ_VN.TAB
 where
      YYYYMMDD  : date
      XXX       : day of the year
      DZZZ      : denotes the DATA-rate of the data in the file, where D is
                  used for original data-rate files from the S/C;
                  values are according to the sheme:
                        D001    for   1 Hz data-rate only
      N         : Version number
Example:
     MAG_20061115_DOY319_D001_V1.TAB
```

- **Data Product RESAMPLED CALIBRATED DATA:**
  = Resampled space magnetic field data , CODMAC Level 4:

```
Position: 12345678901234567890123456 7.123
Filename: MAG_YYYYMMDD_DOYXXX_RZZZ_VN.TAB

where
     YYYYMMDD   : date
     XXX        : day of the year
     RZZZ       : denotes the DATA-rate of the data in the file, with possibilities:
                  (same as defined above for the directory names)
                  SZZZ (Resolution in ZZZ Seconds)
                  MZZZ (Resolution in ZZZ Minutes)
                  HZZZ (Resolution in ZZZ Hours)
     N          : Version number
Example:
     MAG_20061115_DOY319_S004_V1.TAB
```

3.2 Standards Used in Data Product Generation

3.2.1 PDS Standards

MAG complies to PDS version 3, and uses version 3.6 of the PDS standard reference.

3.2.2 Time Standards

Time (UTC) in files: CCJJ-MM-DDT-HH:MM:SS.sss

3.2.3 Reference Systems

- **Spacecraft coordinates** (S/C coordinates): as defined by the spacecraft team;

  Used for all phases of the Venus Express mission for
  RAW SENSOR DATA
  CALIBRATED DATA

- **HSE** : solar ecliptic coordinates, only applicable during the CRUISE phase

  (x,y)-plane is the ecliptic plane,
  x axis positive to the Vernal Equinox,
  z axis positive to Ecliptic North.

  Used for:

  RESAMPLED CALIBRATED DATA in CRUISE phase only.

- **VSO** : Venus solar orbit coordinates

  (x,y) plane is the orbital plane of Venus;
  x-axis is pointing to the solar direction, i.e. on the line Venus-Sun and positive towards the Sun
  y-axis is perpendicular to the x-axis, but positive in direction of negative orbital velocity of Venus
  z-axis completes the right hand system (i.e. z-axis is parallel to the Venus orbital angular momentum vector)

  Used for

  RESAMPLED CALIBRATED DATA after Venus Orbit Insertion only.

3.2.4 Other Applicable Standards

N/A

3.3 Data Validation

Data are checked for self-consistency when decommutating to edited raw format.
Raw synchronized data of MAGIS and MAGOS sensors are compared. They show similar structures, originated in the solar wind, and also spacecraft field effects, which have a smaller effect on the MAGOS sensor.
Before archiving a data set from some mission phase, this set has been used and validated internally by MAG scientists and engineers.

3.4 Content

3.4.1 Volume Set

According to the Planetary Data Sytem Standard Ferference, Version 3.6, Chapter 19, Figure 19.1, i.e. one data-volume is identical to one data-set.

3.4.2 Data Set

The data set name will follow the following convention:

```
DATA_SET_NAME = "<INSTRUMENT_HOST_NAME> <TARGET> <INSTRUMENT_ID>
<data processing level number> <version>"
```

3.4.3 Directories

3.4.3.1 Root Directory

The root directory for the VEX-MAG data is named with the DATA_SET_ID.

File	**Description**	**Responsibility**
AAREADME.TXT	Overview description of contents of dataset	MAG Team
ERRATA.TXT	A text file containing a cumulative listing of comments and updates concerning all MAG standard data products on all MAG volumes in the volume set published to date	MAG Team
VOLDESC.CAT	A description of the contents of this volume in a PSA format readable by both humans and computers	MAG Team

3.4.3.2 Catalog Directory

File	**Description**	**Responsibility**
CATINFO.TXT	A description of the contents of this directory	MAG Team
DATASET.CAT	A description of the MAG dataset in the actual mission phase	MAG Team
INSTHOST.CAT	A description of the Venus Express s/c acting as instrument host for all the experiments.	VSOC
INST.CAT	A complete instrument description of the magnetometer MAG.	MAG team
MISSION.CAT	A description of the Venus Express mission to Venus.	VSOC
PERSON.CAT	PSA personnel catalog description of MAG team members and other persons involved with generation of MAG data products	MAG team
REF.CAT	The file contains publication references of all publications mentioned in the CATALOG files.	MAG team
SOFTWARE.CAT	A description, that there is NO software directory and NO software delivered.	MAG team

3.4.3.3 Index Directory

File	**Description**	**Responsibility**
INDEXINFO.TXT	A description of the contents of this directory	MAG Team
INDEX.TAB	A detailed list of contents for the dataset as generated by the PSA's PVV software	MAG Team
INDEX.LBL	The PSA detached label for the INDEX file	MAG Team

3.4.3.4 Document Directory

File	Description	Responsibility
DOCINFO.TXT	A description of the contents of this directory	MAG team
VE-MAG-EAICD.DOC	The EAICD (this document), in Microsoft Word format	MAG team
VE-MAG-EAICD.PDF	The EAICD in Adobe's Portable Documents Format format	MAG team
VE-MAG-EAICD.TXT	The EAICD in ASCII format	MAG team
VE-MAG-EAICD.LBL	A PSA detached label for the EAICD document	MAG team
ZHANGAL-MAG-ESA-SP1295.DOC	MAG instrument description, ESA SP 2005, in Microsoft Word format	MAG team
ZHANGAL-MAG-ESA-SP1295.PDF	MAG instrument description, ESA SP 2005, in Adobe's Portable Documents Format format	MAG team
ZHANGAL-MAG-ESA-SP1295.TXT	MAG instrument description, ESA SP 2005, in ASCII format	MAG team
ZHANGAL-MAG-ESA-SP1295.LBL	A PSA detached label for the ESA SP 2005 document	MAG team
VE-MAG-SCIENCE-DATA-PROCESSING-DESCRIPTION.DOC	MAG science data processing description, in Microsoft Word format	MAG team
VE-MAG-SCIENCE-DATA-PROCESSING-DESCRIPTION.PDF	MAG science data processing description, in Adobe's Portable Documents Format	MAG team
VE-MAG-SCIENCE-DATA-PROCESSING-DESCRIPTION.TXT	MAG science data processing description, in ASCII format	MAG team
VE-MAG-SCIENCE-DATA-PROCESSING-DESCRIPTION.LBL	A PSA detached label for the MAG science data processing description	MAG team

3.4.3.5 Data Directory

There is a MAG archive data-set for each CODMAC data-level with the structure as described in § 3.1.1

The CODMAC 2 data-set contains data of resolutions 1Hz, 32 Hz, 128 Hz.

The CODMAC 3 data-set contains only data of resolution 1Hz.

The CODMAC 4 data-set contains only data of resolutions lower than 1Hz.

4 Detailed Interface Specifications

4.1 Structure and Organization Overview

From § 3.1.3 we have the following general overview:

```
DATA_SET_ROOT

|---VEX-V/Y-MAG-2-VZ.0                DATA-SET for CODMAC level 2

        AAREADME.TXT
        VOLDESC.CAT

        |--- CATALOG
        |--- DATA
             |--- XXXXXXXXX_D001
                         Filename1 per DOY
                         Filename2 per DOY
                         Etc.
             |--- XXXXXXXXX_D001
        |--- DOCUMENT
        |--- INDEX

|--- VEX-V/Y-MAG-3-VZ.0               DATA-SET for CODMAC level 3


|---VEX-V/Y-MAG-4-VZ.0                DATA-SET for CODMAC level 4
```

4.2 Data Sets, Definition and Content

4.2.1 Data resolution for in-flight products

As already mentioned in

§ 2.2.4 Operation and Data Sampling and
§ 2.5.3 In-Flight Data Products

only in-flight data and measured data are available in the archive.

NO HK data (temperatures, voltages) are injected into the archive, since they are NOT used for calibration.

RAW SENSOR DATA:

- **1 Hz** data (= Solar wind mode) are available with nearly full data coverage for times with the spacecraft in orbit around Venus (after 14 April 2006). in the archive, since all data intervals of higher data rate are down-sampled with the same methods as onboard and merged into the 1 Hz data-set, to enable a full coverage with equidistant samples in time. So 1 Hz data are available for the whole mission duration and nearly without data-gaps, since MAG is ON in principle at ALL times.
- **32 Hz** data are available for short time intervals (2x 10 mins. to 2x 2hours) around pericenter time of the spacecraft.
- **128 Hz** data are available only for several minutes around pericenter time of the spacecraft.

CALIBRATED DATA

Here only **1 Hz** data (= Solar wind mode) are available in the archive.

RESAMPLED CALIBRATED DATA

principally can be available in various resampled data resolutions, but with sampling rate slower than 1 Hz; base line is 4 secs resolution or lower.

4.2.2 Data coverage

For all Venus Express mission phases, data are available on a DAY to DAY basis, i.e. one file per calender day, except where the spacecraft was in safe mode or other non-measuring state.

For normal operation of the spacecraft in orbit, a full 24 hr coverage of the MAG data is offered.

For normal operation of MAG, data-gaps can occurr within the archived daily files; these are due to switching effects of the sensors (from mode to mode), due to lack of good calibration, due to uncorrectable magnetic effects on the spacecraft itself.

4.2.3 Data contents

One data-set is generated per CODMAC level of the data; CODMAC levels were described in § 2.5.3:

CODMAC level 2 = <u>RAW SENSOR DATA</u>
= Raw, synchronized sensor data, data in nano Tesla (nT)

This data type is available for different data resolutions: 1 Hz, 32 Hz, 128 Hz.

WARNING:
Due to the variability of the spacecraft field in the RAW sensor data, these data should be used with caution and in collaboration with the MAG-team.

Data from the two sensors MAG-IS, MAG-OS in S/C coordinates, synchronized, in nano Tesla.
Data are corrected for known sensor-effects, at certain times the data from both sensors still consist of a sifnificant amount of variable spacecraft background field; the ratio of the background spacecraft field at the sensors is variable in time.

UTC, BISX; BISY, BISZ, BIST, BOSX, BOSY, BOSZ, BOST, (BIS-BOS)X, (BIS-BOS)Y, (BIS-BOS)Z, (BIS-BOS)T

UTC:
Time of observation, in universal time
BISX, BISY, BISZ, BIST:
Components of the field and the respective total value (in nT) at the inboard sensor MAG-IS, in S/C coordinates.
BOSX, BOSY, BOSZ, BOST:
Components of the field and the respective total value (in nT) at the outboard sensor MAG-OS, in S/C coordinates.
(BIS-BOS)X, (BIS-BOS)Y, (BIS-BOS)Z, (BIS-BOS)T:
Difference (inboard minus outboard) of the field and the total of the difference (in nT), in S/C coordinates.

The difference is important as indicator for changes in the S/C magnetic state. Constant differences indicate a constant magnetic background field of the S/C; as long as the difference is constant, the calibration can be regarded as stable. Changes in the difference indicate that a change in calibration of the data is required, and this can cause problems.

If any problem is detected in the calibrated data or higher data products, a check of the difference (BIS-BOS) on the respective RAW_SENSOR_DATA file can directly reveal if this is due to a calibration change or not.

The contents is also described in Appendix I.

CODMAC level 3 = <u>CALIBRATED DATA</u>
= Space magnetic field data, in physical units.

This data type is available ONLY for data resolution 1 Hz.

Space magnetic field data in physically meaningful coordinates (HSE;VSO) in nanoTesla; position of S/C in meaningful coordinate system
UTC, BX, BY, BZ, BT, XSC, YSC, ZSC, RSC

UTC:
Time of observation, in universal time
BX, BY, BZ, BT:
Components of the space magnetic field and the respective total in physically meaningful coordinates and in nanoTesla.
XSC, YSC, ZSC, RSC:
Position of the spacecraft in the same coordinate system, in km.

There is NO straight forward relation between the RAW_SENSOR_DATA and CALIBRATED_DATA, but depends on calibration.

If any problem is detected in the calibrated data or higher data products, a check of the difference (BIS-BOS) on the respective RAW_SENSOR_DATA file can directly reveal if this is due to a calibration change or not.

The contents is also described in Appendix II.

CODMAC level 4 = <u>RESAMPLED CALIBRATED DATA</u>
= Averaged space magnetic field data, in physical units.

This data type is available ONLY for data resolution lower than 1 Hz, baseline is 4 secs resolution.

Space magnetic field data in physically meaningful coordinates (HSE, VSO) in nT, averaged from space magnetic field data; position of S/C in meaningful coordinate system
UTC, BX, BY, BZ, BT, XSC, YSC, ZSC, RSC

UTC:
Time of observation, in universal time
BX, BY, BZ, BT:
Averaged components of the space magnetic field and the respective total, in physically meaningful coordinates and in nanoTesla.
XSC, YSC, ZSC, RSC:
Position of the spacecraft in the same coordinate system, in km.

If any problem is detected in the calibrated data or higher data products, a check of the difference (BIS-BOS) on the respective RAW_SENSOR_DATA file can directly reveal if this is due to a calibration change or not.

The contents is also described in Appendix III

4.3 Data Product Design

4.3.1 Data Product Design RAW_SENSOR_DATA

See Appendix I: DATAFILELABEL_CODMAC_2

4.3.2 Data Product Design CALIBRATED_DATA

See Appendix II: DATAFILELABEL_CODMAC_3

4.3.3 Data Product Design RESAMPED_CALIBRATED_DATA

See Appendix III: DATAFILELABEL_CODMAC_4

APPENDIX I: Product Design RAW_SENSOR_DATA, example for 1 Hz data resolution

Keyword SSE Type Description				Example
PDS_VERSION_ID	SC	ID	PDS3	PDS3
LABEL_REVISION_NOTE	SC	CHAR	Release and Revision information	"V1.0"
/* FILE RELATED INFORMATION*/				
PRODUCT_ID	SC	CHAR	Current file name, with extension (example:)	"BIO_20061115_DOY319_D001_V1.TAB"
RECORD_TYPE	SC	ID	FIXED_LENGTH	FIXED_LENGTH
RECORD_BYTES	SC	INT	Record length in bytes, constant	160
FILE_RECORDS	SC	INT	Total file length / RECORD_BYTES (closest integer greater than or equal to this value)	86522 (123 LBL-lines+ 86400 Data-lines)
LABEL_RECORDS	SC	INT	number of physical file records that contain only label information	"BIO_20061115_DOY319_D001_V1.LBL"
SOURCE_NAME	SC	CHAR	Source file name	"BIO_2005-11-20T00-00-32_DOY_324_D001_1_DIF.dat"
/* DATA POINTER IDENTIFICATION */				
^TABLE	SC	PTR	only if Data and Label are in the same file (start at first entry in first data line)	19520
/* PRODUCER IDENTIFICATION */				
PRODUCER_ID	SC	ID	VEX-MAG-TEAM	"VEX_MAG_TEAM"

PRODUCER_FULL_NAME	SC	CHAR	DELVA-ZAMBELLI	"DELVA MAGDA, ZAMBELLI WERNER"
PRODUCER_INSTITUTION_NAME	SC	CHAR	IWF-GRAZ	"INSTITUT FUR WELTRAUMFORSCHUNG – GRAZ"
PRODUCT_CREATION_TIME	SC	TIME		2007-10-18T13:47:13
/* DATA DESCRIPTION AND IDENTIFICATION */				
DATA_SET_NAME	SC	CHAR	Description of the DATA_SET_ID (in words)	"VENUS-EXPRESS VENUS MAG 2 V1.0"
DATA_SET_ID	SC	CHAR		"VEX-V/Y-MAG-2-V1.0"
RELEASE_ID	SC	INT	V1.0	0001
REVISION_ID	SC	INT	V1.0	0000
PRODUCT_TYPE	SC	CHAR	DER (Experiment Data Record)	"EDR"
PROCESSING_LEVEL_ID	SC	INT	CODMAC 2	2
MISSION NAME	SC	CHAR	VENUS EXPRESS	"VENUS EXPRESS"
MISSION_ID	SC	ID	VEX	"VEX"
INSTRUMENT_HOST_NAME	SC	ID	VENUS EXPRESS	"VENUS EXPRESS"
INSTRUMENT_HOST_ID	SC	ID	VEX	"VEX"
MISSION_PHASE_NAME	SC	CHAR	VEX MISSION PHASE (defined from VEX-OrbitNr List)	"PHASE1"
INSTRUMENT_NAME	SC	CHAR	MAG	"MAGNETOMETER"
INSTRUMENT_ID	SC	CHAR	MAG	"MAG"
INSTRUMENT_TYPE	SC	CHAR	MAGNETOMETER	"MAGNETOMETER"
^INSTRUMENT_DESC	SC	CHAR	Pointer to file: INST.CAT	"^INST.CAT"
/* TARGET IDENTIFICATION */				
TARGET_TYPE	SC	CHAR	PLANET	"PLANET"
TARGET_NAME	SC	CHAR	VENUS	"VENUS"

/* TIME RELATED INFORMATION */				
START_TIME SC	SC	TIME		2006-11-15T00:00:00.855
STOP_TIME	SC	TIME		2006-11-15T23:59:59.917
SPACECRAFT_CLOCK_START_COUNT	SC	CHAR	S/C CLOCK TICS	
SPACECRAFT_CLOCK_STOP_COUNT	SC	CHAR	S/C CLOCK TICS	
/* ORBITAL INFORMATION */				
SC_SUN_POSITION_VECTOR		REAL		(141024080.54, -45879280.26, -19810607.77)
SC_TARGET_POSITION_VECTOR		REAL		(1361441.35, -325381.79, -61141.68)
SC_TARGET_VELOCITY_VECTOR		REAL		(-3.85, 0.87, 0.14)
NOTE				"The values of the keywords SC_SUN_POSITION_VECTOR, SC_TARGET_POSITION_VECTOR, SC_TARGET_VELOCITY_VECTOR in Earth Eq. Coord. J2000 are valid for the current day (date) of the file at time T= 00:00:00,. Distances are given in <km> velocities in <km/s>.
PERIAPSIS_TIME		TIME		2006 APR 20 08:07:37
PERIAPSIS_ALTITUDE		REAL	ALTITUDE ABOVE VENUS NOMINAL SURFACE	256,28
SPACECRAFT_ALTITUDE		REAL	SPACECRAFT ALTITUDE	256,28
SUB_SPACECRAFT_LATITUDE		REAL	S/C LATITUDE IN PLANETOCENTRIC COORD.	295,22
SUB_SPACECRAFT_LONGITUDE		REAL	S/C LONGITUDE IN PLANETOCENTRIC COORD.	77,4
ORBIT_NUMBER	SC	INT	ORBIT NR DEFINED BY VSOC	1
NOTE				"The values of the keywords ORBIT_NUMBER,

				SPACECRAFT_ALTITUDE, SUB_SPACECRAFT_LATITUDE, SUB_SPACECRAFT_LONGITUDE are given for PERIAPSIS_TIME, in IAU Venus body fixed coordinates; altitude is in <km>, angles in <degree>"
/* QUALITY IDENTIFICATION */				
DATA_QUALITY_ID	SC	INT	N/A	"N/A"
DATA_QUALITY_DESC	SC	CHAR	N/A	"N/A"
/* INSTRUMENT RELATED INFORMATION*/				
INSTRUMENT_MODE_ID	SC	INT	Solar wind 1	"SW1"
^INSTRUMENT_MODE_CATALOG	SC	CHAR	Pointer to file INST.CAT	"^INST.CAT"
NOTE				"Please note that some of the values in the TABLE object are given in different reference frames. Where this is the case, it is indicated in the DESCRIPTION keyword of the relevant column"
/* OBJECT DEFINITION */				
OBJECT			TABLE	TABLE
NAME		CHAR		MAG RAW_SENSOR_DATA
INTERCHANGE_FORMAT		CHAR		ASCII
ROWS		INT		86400
COLUMNS		INT		13
ROW_BYTES		INT		160
OBJECT			COLUMN	COLUMN
NAME				"TIME_UTC"
COLUMN_NUMBER				1
DATA_TYPE				TIME

START_BYTE				1
BYTES				23
DESCRIPTION				"UTC TIME OF OBSERVATION: YYYY-MM-DDTHH:MM:SS.FFF"
END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"BISX"
COLUMN_NUMBER				2
DATA_TYPE				ASCII_INTEGER
START_BYTE				25
BYTES				10
UNIT				"N/A"
DESCRIPTION				Please note that this value is given in the spacecraft reference frame. Data from MAG inboard sensor at 1Hz, X COMPONENT, in nano Tesla; at certain times a significant amount of variable spacecraft background field is contained in the data. DATA_FLAG_VALUE = 99999.999
END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"BISY"
COLUMN_NUMBER				3
DATA_TYPE				ASCII_INTEGER
START_BYTE				36
BYTES				10
UNIT				"N/A"

DESCRIPTION				Please note that this value is given in the spacecraft reference frame. Data from MAG inboard sensor at 1Hz, Y COMPONENT, in nano Tesla; at certain times a significant amount of variable spacecraft background field is contained in the data. DATA_FLAG_VALUE = 99999.999
END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"BISZ"
COLUMN_NUMBER				4
DATA_TYPE				ASCII_INTEGER
START_BYTE				47
BYTES				10
UNIT				"N/A"
DESCRIPTION				Please note that this value is given in the spacecraft reference frame. Data from MAG inboard sensor at 1Hz, Z COMPONENT, in nano Tesla; at certain times a significant amount of variable spacecraft background field is contained in the data. DATA_FLAG_VALUE = 99999.999
END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"BIST"
COLUMN_NUMBER				5
DATA_TYPE				ASCII_INTEGER
START_BYTE				58
BYTES				10

UNIT				"N/A"
DESCRIPTION				Please note that this value is given in the spacecraft reference frame. Data from MAG inboard sensor at 1Hz, TOTAL field, in nano Tesla; at certain times a significant amount of variable spacecraft background field is contained in the data. DATA_FLAG_VALUE = 99999.999
END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"BOSX"
COLUMN_NUMBER				6
DATA_TYPE				ASCII_INTEGER
START_BYTE				69
BYTES				10
UNIT				"N/A"
DESCRIPTION				Please note that this value is given in the spacecraft reference frame. Data from MAG outboard sensor at 1Hz, X COMPONENT, in nano Tesla; at certain times a significant amount of variable spacecraft background field is contained in the data. . DATA_FLAG_VALUE = 99999.999
END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"BOSY"
COLUMN_NUMBER				7
DATA_TYPE				ASCII_INTEGER
START_BYTE				80
BYTES				10

UNIT				"N/A"
DESCRIPTION				Please note that this value is given in the spacecraft reference frame. Data from MAG outboard sensor at 1Hz, Y COMPONENT, in nano Tesla; at certain times a significant amount of variable spacecraft background field is contained in the data. DATA_FLAG_VALUE = 99999.999
END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"BOSZ"
COLUMN_NUMBER				8
DATA_TYPE				ASCII_INTEGER
START_BYTE				91
BYTES				10
UNIT				"N/A"
DESCRIPTION				Please note that this value is given in the spacecraft reference frame. Data from MAG outboard sensor at 1Hz, Z COMPONENT, in nano Tesla; at certain times a significant amount of variable spacecraft background field is contained in the data. DATA_FLAG_VALUE = 99999.999
END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"BOST"
COLUMN_NUMBER				9
DATA_TYPE				ASCII_INTEGER
START_BYTE				102
BYTES				10

UNIT				"N/A"
DESCRIPTION				Please note that this value is given in the spacecraft reference frame. Data from MAG outboard sensor at 1Hz, TOTAL field, in nano Tesla at certain times a significant amount of variable spacecraft background field is contained in the data DATA_FLAG_VALUE = 99999.999
END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"(BIS-BOS)X"
COLUMN_NUMBER				10
DATA_TYPE				ASCII_INTEGER
START_BYTE				113
BYTES				10
UNIT				"N/A"
DESCRIPTION				Please note that this value is given in the spacecraft reference frame. Data from MAG inboard and outboard sensor at 1Hz, X COMPONENT, in nano Tesla; at certain times a significant amount of variable spacecraft backgroundfield is contained in the data DATA_FLAG_VALUE = 99999.999
END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"(BIS-BOS)Y"
COLUMN_NUMBER				11
DATA_TYPE				ASCII_INTEGER
START_BYTE				124
BYTES				10

UNIT				"N/A"
DESCRIPTION				Please note that this value is given in the spacecraft reference frame. Data from MAG inboard and outboard sensor at 1Hz, Y COMPONENT, in nano Tesla; at certain times a significant amount of variable spacecraft background field is contained in the data DATA_FLAG_VALUE = 99999.999
END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"(BIS-BOS)Z"
COLUMN_NUMBER				12
DATA_TYPE				ASCII_INTEGER
START_BYTE				135
BYTES				10
UNIT				"N/A"
DESCRIPTION				Please note that this value is given in the spacecraft reference frame. Data from MAG inboard and outboard sensor at 1Hz, Z COMPONENT, in nano Tesla; at certain times a significant amount of variable spacecraft background field is contained in the data DATA_FLAG_VALUE = 99999.999
END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"(BIS-BOS)T"
COLUMN_NUMBER				13
DATA_TYPE				ASCII_INTEGER
START_BYTE				146
BYTES				10

UNIT				"N/A"
DESCRIPTION				Please note that this value is given in the spacecraft reference frame. Data from MAG inboard and outboard sensor at 1Hz, total, in nano Tesla; at certain times a significant amount of variable spacecraft background field is contained in the data DATA_FLAG_VALUE = 99999.999
END OBJECT				COLUMN
END_OBJECT				
END				

APPENDIX II: Product Design CALIBRATED_DATA, 1 Hz data-resolution only

Keyword SSE Type Description				Example
PDS_VERSION_ID	SC	ID	PDS3	PDS3
LABEL_REVISION_NOTE	SC	CHAR	Release and Revision information	"V1.0"
/* FILE RELATED INFORMATION*/				
PRODUCT_ID	SC	CHAR	Current file name, with extension (example:)	"MAG_20061115_DOY319_D001_V1.TAB"
RECORD_TYPE	SC	ID	FIXED_LENGTH	FIXED_LENGTH
RECORD_BYTES	SC	INT	Record length in bytes, constant	160
FILE_RECORDS	SC	INT	Total file length / RECORD_BYTES (closest integer greater than or equal to this value)	86522 (123 LBL-lines+ 86400 Data-lines)
LABEL_RECORDS	SC	INT	only if Data and Label are in different files	"MAG_20061115_DOY319_D001_V1.LBL"
SOURCE_NAME	SC	CHAR	Source file name	BAM_2006-11-15T00-00-01_DOY_319_D001_3_VSO_SAP.dat
/* DATA POINTER IDENTIFICATION */				
^TABLE	SC	PTR	only if Data and Label are in the same file (start at first entry in first data line)	19520
/* PRODUCER IDENTIFICATION */				
PRODUCER_ID	SC	ID	VEX-MAG-TEAM	"VEX_MAG_TEAM"
PRODUCER_FULL_NAME	SC	CHAR	DELVA-ZAMBELLI	"DELVA MAGDA, ZAMBELLI WERNER"
PRODUCER_INSTITUTION_NAME	SC	CHAR	IWF-GRAZ	"INSTITUT FUR WELTRAUMFORSCHUNG – GRAZ"

PRODUCT_CREATION_TIME	SC	TIME		2006-10-16T08:12:37
/* DATA DESCRIPTION AND IDENTIFICATION */				
DATA_SET_NAME	SC	CHAR	Description of the DATA_SET_ID (in words)	"VENUS-EXPRESS VENUS MAG 3 V1.0"
DATA_SET_ID	SC	CHAR		"VEX-V-MAG-3-V1.0"
RELEASE_ID	SC	INT	V**1**.0	0001
REVISION_ID	SC	INT	V1.**0**	0000
PRODUCT_TYPE	SC	ID	RDR (Reduced Data Record)	"RDR"
PROCESSING_LEVEL_ID	SC	INT	CODMAC 3	3
MISSION NAME	SC	CHAR	VENUS EXPRESS	"VENUS EXPRESS"
MISSION_ID	SC	ID	VEX	"VEX"
INSTRUMENT_HOST_NAME	SC	ID	VENUS EXPRESS	"VENUS EXPRESS"
INSTRUMENT_HOST_ID	SC	ID	VEX	"VEX"
MISSION_PHASE_NAME	SC	CHAR	VEX MISSION PHASE (defined from VEX-OrbitNr List)	"PHASE1"
INSTRUMENT_NAME	SC	CHAR	MAG	"MAGNETOMETER"
INSTRUMENT_ID	SC	CHAR	MAG	"MAG"
INSTRUMENT_TYPE	SC	CHAR	MAGNETOMETER	"MAGNETOMETER"
^INSTRUMENT_DESC	SC	CHAR	Pointer to file: INST.CAT	"^INST.CAT"
/* TARGET IDENTIFICATION */				
TARGET_TYPE	SC	CHAR	PLANET	"PLANET"
TARGET_NAME	SC	CHAR	VENUS	"VENUS"
/* TIME RELATED INFORMATION */				
START_TIME SC	SC	TIME		2006-11-15T00:00:00.855
STOP_TIME	SC	TIME		2006-11-15T23:59:59.917

SPACECRAFT_CLOCK_START_COUNT	SC	CHAR	S/C CLOCK TICS	
SPACECRAFT_CLOCK_STOP_COUNT	SC	CHAR	S/C CLOCK TICS	
/* ORBITAL INFORMATION */				
SC_SUN_POSITION_VECTOR		REAL		(141024080.54, -45879280.26, -19810607.77)
SC_TARGET_POSITION_VECTOR		REAL		(1361441.35, -325381.79, -61141.68)
SC_TARGET_VELOCITY_VECTOR		REAL		(-3.85, 0.87, 0.14)
NOTE				"The values of the keywords SC_SUN_POSITION_VECTOR, SC_TARGET_POSITION_VECTOR, SC_TARGET_VELOCITY_VECTOR in Earth Eq. Coord. J2000 are valid for the current day (date) of the file at time T= 00:00:00,. Distances are given in <km> velocities in <km/s>.
PERIAPSIS_TIME		TIME		2006 APR 20 08:07:37
PERIAPSIS_ALTITUDE		REAL	ALTITUDE ABOVE VENUS NOMINAL SURFACE	256,28
SPACECRAFT_ALTITUDE		REAL	SPACECRAFT ALTITUDE	256,28
SUB_SPACECRAFT_LATITUDE		REAL	S/C LATITUDE IN PLANETOCENTRIC COORD.	295,22
SUB_SPACECRAFT_LONGITUDE		REAL	S/C LONGITUDE IN PLANETOCENTRIC COORD.	77,4
ORBIT_NUMBER	SC	INT	ORBIT NR DEFINED BY VSOC	1
NOTE				"The values of the keywords ORBIT_NUMBER, SPACECRAFT_ALTITUDE, SUB_SPACECRAFT_LATITUDE, SUB_SPACECRAFT_LONGITUDE are given for

				PERIAPSIS_TIME, in IAU Venus body fixed coordinates;; altitude is in <km>, angles in degrees"
/* QUALITY IDENTIFICATION */				
DATA_QUALITY_ID	SC	INT	N/A	"N/A"
DATA_QUALITY_DESC	SC	CHAR	N/A	"N/A"
/* INSTRUMENT RELATED INFORMATION*/				
INSTRUMENT_MODE_ID	SC	INT	Solar wind 1	"SW1"
^INSTRUMENT_MODE_DESC	SC	CHAR	Pointer to file INST.CAT	"^INST.CAT"
/* OBJECT DEFINITIONS */				
OBJECT			TABLE	TABLE
NAME		CHAR		MAG CALIBRATED_DATA
INTERCHANGE_FORMAT		CHAR		ASCII
ROWS		INT		86400
COLUMNS		INT		9
ROW_BYTES		INT		113
OBJECT			COLUMN	COLUMN
NAME				"TIME_UTC"
COLUMN_NUMBER				1
DATA_TYPE				TIME
START_BYTE				1
BYTES				23
DESCRIPTION				"UTC TIME OF OBSERVATION: YYYY-MM-DDTHH:MM:SS.FFF"
END OBJECT				COLUMN

OBJECT			COLUMN	COLUMN
NAME				"BX"
COLUMN_NUMBER				2
DATA_TYPE				ASCII_INTEGER
START_BYTE				25
BYTES				10
UNIT				"NANOTESLA"
UNIT_ID				"nT"
DESCRIPTION				SPACE MAGNETIC FIELD, CALIBRATED, X COMPONENT in Venus Solar Orbital (VSO) coordinates, in nanoTesla DATA_FLAG_VALUE = 99999.999
END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"BY"
COLUMN_NUMBER				3
DATA_TYPE				ASCII_INTEGER
START_BYTE				36
BYTES				10
UNIT				"NANOTESLA"
UNIT_ID				"nT"
DESCRIPTION				SPACE MAGNETIC FIELD, CALIBRATED, Y COMPONENT, in Venus Solar Orbital (VSO) coordinates, in nanoTesla DATA_FLAG_VALUE = 99999.999
END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"BZ"

COLUMN_NUMBER				4
DATA_TYPE				ASCII_INTEGER
START_BYTE				47
BYTES				10
UNIT				"NANOTESLA"
UNIT_ID				"nT"
DESCRIPTION				SPACE MAGNETIC FIELD, CALIBRATED, Z COMPONENT, in Venus Solar Orbital (VSO) coordinates, in nanoTesla DATA_FLAG_VALUE = 99999.999
END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"BT"
COLUMN_NUMBER				5
DATA_TYPE				ASCII_INTEGER
START_BYTE				58
BYTES				10
UNIT				"NANOTESLA"
UNIT_ID				"nT"
DESCRIPTION				SPACE MAGNETIC FIELD, CALIBRATED, TOTAL. DATA_FLAG_VALUE = 99999.999
END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"XSC"
COLUMN_NUMBER				6
DATA_TYPE				ASCII_INTEGER
START_BYTE				69

BYTES				10
UNIT				"KILOMETER"
UNIT_ID				"km"
DESCRIPTION				SPACECRAFT POSITION, X COMPONENT, in Venus Solar Orbital (VSO) coordinates, in kilometer
END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"YSC"
COLUMN_NUMBER				7
DATA_TYPE				ASCII_INTEGER
START_BYTE				80
BYTES				10
UNIT				"KILOMETER"
UNIT_ID				"km"
DESCRIPTION				SPACECRAFT POSITION, Y COMPONENT , in Venus Solar Orbital (VSO) coordinates, in kilometer
END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"ZSC"
COLUMN_NUMBER				8
DATA_TYPE				ASCII_INTEGER
START_BYTE				91
BYTES				10
UNIT				"KILOMETER"
UNIT_ID				"km"
DESCRIPTION				SPACECRAFT POSITION, Z COMPONENT , in Venus Solar Orbital (VSO) coordinates, in kilometer

END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"RSC"
COLUMN_NUMBER				9
DATA_TYPE				ASCII_INTEGER
START_BYTE				102
BYTES				10
UNIT				"KILOMETER"
UNIT_ID				"km"
DESCRIPTION				SPACECRAFT POSITION, DISTANCE R , in Venus Solar Orbital (VSO) coordinates, in kilometer
END OBJECT				COLUMN
END_OBJECT				
END				

APPENDIX III: Product Design RESAMPLED_CALIBRATED_DATA

Keyword SSE Type Description				Example
PDS_VERSION_ID	SC	ID	PDS3	PDS3
LABEL_REVISION_NOTE	SC	CHAR	Release and Revision information	"V1.0"
/* FILE RELATED INFORMATION*/				
PRODUCT_ID	SC	CHAR	Current file name, with extension (example:)	"MAG_20061115_DOY319_S004_V1.TAB"
RECORD_TYPE	SC	ID	FIXED_LENGTH	FIXED_LENGTH
RECORD_BYTES	SC	INT	Record length in bytes, constant	130
FILE_RECORDS	SC	INT	Total file length / RECORD_BYTES (closest integer greater than or equal to this value)	21723 (123 LBL-lines+ 21600 Data-lines)
LABEL_RECORDS	SC	INT	only if Data and Label are in different files	"MAG_20061115_DOY319_S004_V1.LBL"
SOURCE_NAME	SC	CHAR	Source file name	MAG_2006-11-15T00-00-00_DOY_319_S004_3_VSO_SAP.dat
/* DATA POINTER IDENTIFICATION */				
^TABLE	SC	PTR	only if Data and Label are in the same file (start at first entry in first data line)	19520
/* PRODUCER IDENTIFICATION */				
PRODUCER_ID	SC	ID	VEX-MAG-TEAM	"VEX_MAG_TEAM"
PRODUCER_FULL_NAME	SC	CHAR	DELVA-ZAMBELLI	"DELVA MAGDA, ZAMBELLI WERNER"
PRODUCER_INSTITUTION_NAME	SC	CHAR	IWF-GRAZ	"INSTITUT FUR WELTRAUMFORSCHUNG – GRAZ"

PRODUCT_CREATION_TIME	SC	TIME		2007-10-18T13:47:13
/* DATA DESCRIPTION AND IDENTIFICATION */				
DATA_SET_NAME	SC	CHAR	Description of the DATA_SET_ID (in words)	"VENUS-EXPRESS VENUS MAG 4 V1.0"
DATA_SET_ID	SC	CHAR		"VEX-V/Y-MAG-4-V1.0"
RELEASE_ID	SC	INT	V1.0	0001
REVISION_ID	SC	INT	V1.0	0000
PRODUCT_TYPE	SC	CHAR	REFDR (Reformatted (Resampled))	"REFDR"
PROCESSING_LEVEL_ID	SC	INT	CODMAC 4	4
MISSION NAME	SC	CHAR	VENUS EXPRESS	"VENUS EXPRESS"
MISSION_ID	SC	ID	VEX	"VEX"
INSTRUMENT_HOST_NAME	SC	ID	VENUS EXPRESS	"VENUS EXPRESS"
INSTRUMENT_HOST_ID	SC	ID	VEX	"VEX"
MISSION_PHASE_NAME	SC	CHAR	VEX MISSION PHASE (defined from VEX-OrbitNr List)	"PHASE1"
INSTRUMENT_NAME	SC	CHAR	MAG	"MAGNETOMETER"
INSTRUMENT_ID	SC	CHAR	MAG	"MAG"
INSTRUMENT_TYPE	SC	CHAR	MAGNETOMETER	"MAGNETOMETER"
^INSTRUMENT_DESC	SC	CHAR	Pointer to file: INST.CAT	"^INST.CAT"
/* TARGET IDENTIFICATION */				
TARGET_TYPE	SC	CHAR	PLANET	"PLANET"
TARGET_NAME	SC	CHAR	VENUS	"VENUS"
/* TIME RELATED INFORMATION */				
START_TIME SC	SC	TIME		2006-11-15T00:00:00.855
STOP_TIME	SC	TIME		2006-11-15T23:59:59.917

SPACECRAFT_CLOCK_START_COUNT	SC	CHAR	S/C CLOCK TICS	
SPACECRAFT_CLOCK_STOP_COUNT	SC	CHAR	S/C CLOCK TICS	
/* ORBITAL INFORMATION */				
SC_SUN_POSITION_VECTOR		REAL		(141024080.54, -45879280.26, -19810607.77)
SC_TARGET_POSITION_VECTOR		REAL		(1361441.35, -325381.79, -61141.68)
SC_TARGET_VELOCITY_VECTOR		REAL		(-3.85, 0.87, 0.14)
NOTE				"The values of the keywords SC_SUN_POSITION_VECTOR, SC_TARGET_POSITION_VECTOR, SC_TARGET_VELOCITY_VECTOR in Earth Eq. Coord. J2000 are valid for the current day (date) of the file at time T= 00:00:00,. Distances are given in <km> velocities in <km/s>.
PERIAPSIS_TIME		TIME		2006 APR 20 08:07:37
PERIAPSIS_ALTITUDE		REAL	ALTITUDE ABOVE VENUS NOMINAL SURFACE	256,28
SPACECRAFT_ALTITUDE		REAL	SPACECRAFT ALTITUDE	256,28
SUB_SPACECRAFT_LATITUDE		REAL	S/C LATITUDE IN PLANETOCENTRIC COORD.	295,22
SUB_SPACECRAFT_LONGITUDE		REAL	S/C LONGITUDE IN PLANETOCENTRIC COORD.	77,4
ORBIT_NUMBER	SC	INT	ORBIT NR DEFINED BY VSOC	1
NOTE				"The values of the keywords ORBIT_NUMBER, SPACECRAFT_ALTITUDE, SUB_SPACECRAFT_LATITUDE, SUB_SPACECRAFT_LONGITUDE are given for

				PERIAPSIS_TIME; altitude is in <km>, angles in degrees"
/* QUALITY IDENTIFICATION */				
DATA_QUALITY_ID	SC	INT	N/A	"N/A"
DATA_QUALITY_DESC	SC	CHAR	N/A	"N/A"
/* INSTRUMENT RELATED INFORMATION*/				
INSTRUMENT_MODE_ID	SC	INT	Solar wind 1	"SW1"
^INSTRUMENT_MODE_CATALOG	SC	CHAR	Pointer to file INST.CAT	"^INST.CAT"
NOTE				"Please note that some of the values in the TABLE object are given in different reference frames. Where this is the case, it is indicated in the DESCRIPTION keyword of the relevant column"
/* OBJECT DEFINITION */				
OBJECT			TABLE	TABLE
NAME		CHAR		MAG RESAMPLED_CALIBRATED_DATA
INTERCHANGE_FORMAT		CHAR		ASCII
ROWS		INT		21600
COLUMNS		INT		9
ROW_BYTES		INT		130
OBJECT			COLUMN	COLUMN
NAME				"TIME_UTC"
COLUMN_NUMBER				1
DATA_TYPE				TIME
START_BYTE				1
BYTES				23

DESCRIPTION				"UTC TIME OF OBSERVATION: YYYY-MM-DDTHH:MM:SS.FFF"
END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"BX"
COLUMN_NUMBER				2
DATA_TYPE				ASCII_INTEGER
START_BYTE				25
BYTES				10
UNIT				"NANOTESLA"
UNIT_ID				"nT"
DESCRIPTION				SPACE MAGNETIC FIELD, RESAMPLED, CALIBRATED, X COMPONENT, in Venus Solar Orbital (VSO) coordinates, in nanoTesla DATA_FLAG_VALUE = 99999.999
END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"BY"
COLUMN_NUMBER				3
DATA_TYPE				ASCII_INTEGER
START_BYTE				36
BYTES				10
UNIT				"NANOTESLA"
UNIT_ID				"nT"
DESCRIPTION				SPACE MAGNETIC FIELD, RESAMPLED, CALIBRATED, Y COMPONENT, in Venus Solar Orbital (VSO) coordinates, in nanoTesla DATA_FLAG_VALUE = 99999.999

END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"BZ"
COLUMN_NUMBER				4
DATA_TYPE				ASCII_INTEGER
START_BYTE				47
BYTES				10
UNIT				"NANOTESLA"
UNIT_ID				"nT"
DESCRIPTION				SPACE MAGNETIC FIELD, RESAMPLED, CALIBRATED, Z COMPONENT, in Venus Solar Orbital (VSO) coordinates, in nanoTesla DATA_FLAG_VALUE = 99999.999
END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"BT"
COLUMN_NUMBER				5
DATA_TYPE				ASCII_INTEGER
START_BYTE				58
BYTES				10
UNIT				"NANOTESLA"
UNIT_ID				"nT"
DESCRIPTION				SPACE MAGNETIC FIELD, RESAMPLED, CALIBRATED, TOTAL COMPONENT, , in Venus Solar Orbital (VSO) coordinates, in nanoTesla DATA_FLAG_VALUE = 99999.999
END OBJECT				COLUMN

OBJECT			COLUMN	COLUMN
NAME				"XSC"
COLUMN_NUMBER				6
DATA_TYPE				ASCII_INTEGER
START_BYTE				69
BYTES				10
UNIT				"KILOMETER"
UNIT_ID				"km"
DESCRIPTION				SPACECRAFT POSITION, X COMPONENT, in Venus Solar Orbital (VSO) coordinates, in kilometer
END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"YSC"
COLUMN_NUMBER				7
DATA_TYPE				ASCII_INTEGER
START_BYTE				80
BYTES				10
UNIT				"KILOMETER"
UNIT_ID				"km"
DESCRIPTION				SPACECRAFT POSITION, Y COMPONENT, in Venus Solar Orbital (VSO) coordinates, in kilometer
END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"ZSC"
COLUMN_NUMBER				8
DATA_TYPE				ASCII_INTEGER

START_BYTE				91
BYTES				10
UNIT				"KILOMETER"
UNIT_ID				"km"
DESCRIPTION				SPACECRAFT POSITION, Z COMPONENT, in Venus Solar Orbital (VSO) coordinates, in kilometer
END OBJECT				COLUMN
OBJECT			COLUMN	COLUMN
NAME				"RSC"
COLUMN_NUMBER				9
DATA_TYPE				ASCII_INTEGER
START_BYTE				102
BYTES				10
UNIT				"KILOMETER"
UNIT_ID				"km"
DESCRIPTION				SPACECRAFT POSITION, R COMPONENT, in Venus Solar Orbital (VSO) coordinates, in kilometer
END OBJECT				COLUMN
END_OBJECT				
END				