Stanford Center for Radar Astronomy

Magellan Project

Software Interface Specification

SU-MGN-SCVDR

Surface Characteristics Vector Data Record

prepared by

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Version 1.0
1 October 1992

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DOCUMENT CHANGE LOG

REVISION NUMBER	REVISION DATE	SECTION AFFECTED	REMARKS
0.8	26 June 92	All	Major upgrade of details following review by Project and interested scientists; overall logical structure not affected appreciably. ANSI labeled tapes become tar tapes.
1.0	29 Sept 92	Distrib-ution.	Add Joyner, Anderson, Saunders, Hinnen update addresses; improve layout/ alignments.
1.0	29 Sept 92	Table of Contents	add page numbers
1.0	29 Sept 92	1.3	Consolidate descriptions of Stanford software into a single (as yet unwritten) document; renumber other Applicable Documents (and references to them in subsequent sections).
1.0	29 Sept 92	1.4.1	Add DEC DS3100 to list of workstations
1.0	29 Sept 92	2.3.2	Substitute semicolon between "last" and "version"
1.0	29 Sept 92	5.1.3	Substitute "even-numbered" for "even" in footnote
1.0	29 Sept 92	5.1.3	Remove extraneous "f" at end of lines for NAV_UNIQUE_ID and PROCESS_TIME
1.0	29 Sept 92	5.3 5.4 5.5 5.6 5.7 5.8	Substitute real ADIDs assigned by JPL SFDU Control Authority
1.0	29 Sept 92	5.4.1 5.6 5.7 5.8	Add nh_maxB and nh_maxN Add ih_maxB and ih_maxI Add eh_meth_syst, eh_meth_geom, eh_meth_telem, eh_pad er_ss_prev[10], er_Sprime, er_Tsen, and er_pad3 Add gh_maxB, gh_maxR, gh_maxF, gh_maxBR, and eh_maxBF

REVISION NUMBER	REVISION DATE	SECTION AFFECTED	REMARKS
1.0	29 Sept 92	5.4.1 5.5	Add explanation for "insensitive" version numbers under definitions for nh_ver, fh_ver
1.0	29 Sept 92	5.4.2	Correct definition for nr_burst
1.0	29 Sept 92	Table 5-9	Add description of method used to obtain rms slope from Muhleman function
1.0	29 Sept 92	Table 5-12	Substitute 90 for 75
1.0	29 Sept 92	5.6	Move bin_t description from footnote to become new Table 5-12; renumber following tables
1.0	29 Sept 92	5	Adopt consistent use of uchar (unsigned 8-bit integer) and char (character text)
1.0	29 Sept 92	All	Minor editorial corrections/ improvements

ITEMS TO BE DETERMINED

REVISION NUMBER	SECTION AFFECTED	ITEM DESCRIPTION	RESOLUTION
0.5	Contents	Fill in page numbers	done
0.5	1.3	Flesh out and reorder Applicable Documents section	done
0.5	Several	Need JPL Control Authority designation for: Orbit Header Record Altimetry Inversion Record Inversion Fit Record Image Data Record Emissivity Data Record Stanford G-Matrix Record Altimetry Inversion Aggregation Inversion Fit Aggregation Image Data Aggregation Emissivity Data Aggregation G-Matrix Aggregation Altimetry Inversion Header Inversion Fit Header Image Header Emissivity Header G-Matrix Header	done
0.5	Table 5-9	Definition for Muhleman function rms; is present expression for so?	done
0.8	1.3	Write summary document(s) on processing which precedes the SCVDR step, Applicable Doc 9	
0.8	4.2.1	Include reference to SFOC-5-SYS-*DU-NJPL and/or TPS-113?	not done
0.8	Table 5-7	Revise to show each solution result as a separate substructure	not done
0.8	Footnote	Move bin_t definition from footnote to a table of its own	done
0.8	all	Types char and uchar are not consistently used throughout the document	made consistent

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ACRONYMS AND ABBREVIATIONS

ALT	Altimeter
ALT-EDR	Altimetry Experiment Data Record (tape)
ALTINV	Stanford Altimetry Inversion (program)
ANF	Altimetry Inversion File of the SCVDR
ANSI	American National Standards Institute
ARCDR	Altimetry and Radiometry Composite Data Record
ASCII	American Standard Code for Information Interchange
C-BIDR	Compressed Basic Image Data Record (tape)
CCSDS	Consultative Committee for Space Data Systems
CCT	Computer Compatible Tape
COMP	Stanford amplitude and timing compensation (program)
dB	Decibel
DMAT	Data Management and Archive Team
EDF	Emissivity Data File of the SCVDR
EDR	Experiment Data Record
ENGEX	Engineering data extraction and conditioning (program)
FIR	Finite Impulse Response
GIPS	MIT General Image Processing System (program)
GMF	G-Matrix File of the SCVDR
GMX	Stanford G-Matrix calculation (program)
GVDR	Global Vector Data Record
IEEE	Institute of Electrical and Electronic Engineering
IAU	International Astronomical Union
ID	identifier, identification
JPL	Jet Propulsion Laboratory
J2000	IAU Official Time Epoch
K	Degrees Kelvin
km	Kilometers
MGN	Magellan
MIT	Massachusetts Institute of Technology
MLOAD	Stanford Magnetic Tape Loading (program)
NAIF	Navigation and Ancillary Information Facility
NAV	Navigation Subsystem/Team
ODL	Object Definition Language (PDS)
OHF	Orbit Header File of the SCVDR
OHR	Orbit Header Record
OIF	Oblique Sinusoidal Equal Area Image Data File
ONU	Output Network Unit
PDS	Planetary Data System
RADI	Stanford emissivity processing (program)
RADP	Processing Parameters consolidation for radiometry (program)
RATM	Atmospheric radiative transfer calculation (program)
RCOMP	Radiometry compensation (program)
RMAP	Stanford compressed image reduction (program)
SAB	SAR/Altimeter Burst
SABEX	SAB header extraction (program)
SAR	Synthetic Aperture Radar

SCET	Space Craft Event Time
SCLK	Spacecraft Clock (time)
SCVDR	Surface Characteristics Vector Data Record
SFDU	Standard Formatted Data Unit
SFOC	Space Flight Operations Center
SIF	Sinusoidal Equal Area Image Data File
SIS	Software Interface Specification
SPARC	Sun Scalable Processor Architecture
SPK	Spacecraft and Planet Kernel Format, from NAIF
SSLFIT	Stanford Synthetic Scattering Law Fit (program)
UTC	Coordinated Universal Time
tar	(UNIX) tape archiver utility
TBD	To Be Determined
TDB	Temps Dynamique Barycentrique-IAU Standard Ephemeris Time
UNIX	operating system
VBF85	Venus Body Fixed Coordinates, adopted by the IAU in 1985
VHF	Volume Header File of the SCVDR
VTF	Volume Trailer File of the SCVDR

CHAPTER 1

General Description

1.1. Overview

This Software Interface Specification (SIS) contains the description of the Surface Characteristics Vector Data Record (SCVDR) tapes produced for the Magellan (MGN) Project. The Magellan Project is managed by the Jet Propulsion Laboratory (JPL); SCVDR tapes are created at Stanford University. SCVDR tapes contain results of processing Magellan altimetry, SAR image, and emissivity[1] data to obtain electrical and physical properties of Venus' surface [1].

1.2. Scope

The format and content specifications in this SIS apply to all phases of the Magellan Project for which the SCVDR is produced.

1.3. Applicable Documents

(1) Tyler, G.L., R.A. Simpson, M.J. Maurer, and E. Holmann, ''Scattering properties of the Venusian surface: preliminary results from Magellan,'' J. Geophys. Res., 97, 13115-13139, 1992.

(2) **MGN 630-79**, Rev. D, ''Magellan Planetary Constants and Models'', D.T. Lyons, Magellan Mission Design, JPL, January 9, 1991.

(3) **MIT-MGN-ARCDR**, Software Interface Specification, Altimetry and Radiometry Composite Data Record, MIT Center for Space Research, 12 September 1991.

(4) **ANSI X3.27-1978**, American National Standards Institute, Magnetic Tape Labels for Information Exchange, Appendix X, Label and Volume Organization, April 18, 1977.

(5) **JJPL-0006-01-00**, JPL SFDU Description and Usage. Issue 5, March 7 1988.

(6) **D-7669**, Planetary Data System - Data Preparation Workbook, Version 2.0, Jet Propulsion Laboratory, 3 May 1991.

(7) **SFOC-2-DPS-CDB-Ephemeris**, NAIF Ephemeris File, JPL Navigation Ancillary Information Facility, July 15, 1988.

(8) **SDPS-101**, Full-Resolution Basic Image Data Record, Revision D, Jet Propulsion Laboratory, 6 March 1992.

(9) Simpson, R.A., M.J. Maurer, and E. Holmann, Stanford Magellan Data Processing System, TBD.

(10) **MGN-IDPS-102**, Magellan Software Interface Specification, Compressed-resolution Basic Image Data, JPL, February 14, 1990.

(11) **HS513-5029**, Magellan Radar Sensor Compensation Report, ed. C. Cuevas, Hughes Aircraft Corporation, 18 August 1989.

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[1] Throughout this document, we will often refer to passive measurement of thermal radiation from Venus as emissivity measurements; the SCVDR records and files that contain data from those measurements will be called emissivity records and emissivity files. Our MIT colleagues use the same spacecraft data and have generated records and files which they call radiometry results [8] that share many of the same attributes. We make the distinction in wording solely to emphasize that the Stanford and MIT data sets, although in many ways comparable, are in fact different.

(12) **D-4613**, Magellan Mission Operations System-Radar Interface Requirements Document (630-204), Hughes Aircraft Corporation, May 1987.

(13) **SFOC-1-CDB-MGN-SCLKvSCET**, Magellan SCLK/SCET Coefficients File, Final, 2 November 1989.

1.4. System Siting

1.4.1. Interface Location and Medium

SCVDR tapes are created by the Stanford Magellan processing system, which consists of DEC DS3100, DEC DS5000, Sun 4/110, and Sun SPARC-2 workstations; a DECsystem 5400 file server; and associated peripherals.

1.4.2. Data Sources, Transfer Methods, and Destinations

SCVDR tapes contain files created by the Stanford Magellan processing system. Input to the SCVDR is provided by programs [1,9]:

MLOAD loads original data from tape to disk, and removes SFDU headers

ALT carries out pulse compression and Fourier analysis on data from ALT-EDR tapes; results from this step are saved as range-Doppler arrays

GMX computes matrices, dependent on geometrical factors, which are required by the altimetry inversion program ALTINV

ALTINV converts altimetry range-Doppler arrays to estimates of the surface scattering function near nadir

SSLFIT fits analytic scattering functions to the scattering function solutions provided by ALTINV

RMAP reduces compressed image data (from C-BIDR tapes) to estimates of the surface scattering function at oblique angles and pixel histograms

RADI converts measurements of Venus' microwave thermal emission to estimates of surface brightness and emissivity

COMP computes radiometric compensation for altimetry system

RADP converts Processing Parameters files associated with sinusoidal and oblique image data into a single file for use by RADI

ENGEX extracts and conditions specified channels from telemetry stream, using DECOM/DECAL and ENGINEERING files (and MIT decommutation module)

SABEX extracts SAB headers from SAB_HEADER file and saves for input to RADI

RCOMP performs radiometric and timing compensation for RADI; uses HAC algorithms and atmospheric model results from RATM

RATM computes atmospheric brightness and attenuation based on Magellan-adopted standard model and refinements

SCVDRs are written on 8 mm cartridge tapes using the UNIX tar utility. Product tapes are provided to the MGN Data Management and Archive Team (DMAT), which forwards the tapes to Magellan users.

1.4.3. Generation Method and Frequency

SCVDR tapes are generated by reformatting and manipulating output files from Stanford programs MLOAD, ALTINV, SSLFIT, RMAP, RADI, and GMX. Each SCVDR contains data from up to 100 sequential orbits. SCVDRs are generated when the data for the appropriate orbits become available.

1.5. Assumptions and Constraints

1.5.1. Usage Constraints

None.

1.5.2. Priority Phasing Constraints

None.

1.5.3. Explicit and Derived Constraints

None.

1.5.4. Documentation Conventions

1.5.4.1. Data Format Descriptions

The reference data unit is the byte. In the SCVDR, data are stored in fields with various sizes and formats, viz. one-, two-, and four-byte binary integers, four- and eight-byte binary floating-point numbers, and strings of characters. Data are identified throughout this document as

char	8 bits	character
short	16 bits	integer
long	32 bits	integer
float	32 bits	floating point (sign, exponent, and mantissa)
double	64 bits	floating point (sign, exponent, and mantissa)
u (prefix)		unsigned (as with ulong for unsigned 32-bit integer, uchar is an unsigned 8-bit integer)
other		special data structures such as sfdu, calib_t, etc. which are described within this document

The detailed formats of the numeric fields of the product tapes are defined in Appendix A.

If a field is described as containing n bytes of ASCII character string data, this implies that the leftmost (lowest numbered) byte contains the first character, the next lowest byte contains the second character, and so forth. Character strings are written to tape with lower numbered bytes preceding higher numbered bytes.

An array of n elements is written as array[n]; the first element is array[0], and the last is array[n–1]. Array[n][m] describes an n m element array, with first element array[0][0], second element array[0][1], and so forth-according to C language conventions, not FORTRAN conventions.

1.5.4.2. Time Standards

The SCVDR uses the January 1.5, 2000 epoch as the standard time for Spacecraft Event Time (SCET). Within the data files, all times are reported in Spacecraft Event Time, expressed as a binary double precision data field representing the number of elapsed seconds of Ephemeris Time (TDB) since noon, January 1, 2000 [2].

The SCVDR uses a string of 23 ASCII characters when a local time, such as the time that a certain processing activity began, is required. The format is `YYYY-MM-DDThh:mm:ss.fff´, where `-´, `T´, `:´, and `.´ are fixed delimiters; `YYYY´ is the year `19nn´ or `20nn´; `MM´ is a two-digit month of year; `DD´ is a two-digit day of month; `T´ separates the date and time segments of the string; `hh´ is hour of day; `mm´ is the minutes of hour (00–59); `ss´ is the seconds of hour (00–59); and `fff´ is in milliseconds. "Local" times are given in Coordinated Universal Time (UTC).

1.5.4.3. Coordinate Systems

The SCVDR uses two coordinate systems—the J2000 coordinate system and the VBF85 coordinate system [2].

1.5.4.4. Limits of This Document

This document applies only to the SCVDR product.

1.5.4.5. Typographic Conventions

To make Section 5 of this document more readable, the following combinations of fonts and typefaces are used for special purposes:

Boldface for symbolic names of SFDU components, e.g. **length field**.

`Typewriter` for label keywords and all other ASCII character string values (for example, `'CCSD1Z000001'`, always enclosed in quotation marks), decimal values (for example, `1990`, with no quotes), and hexadecimal values (for example, `0xff`, with leading `0x`).

1.6. Acknowledgement

This document, and the product it defines, have been deliberately modeled after the Magellan ARCDR product from the MIT Center for Space Research [3]. The ARCDR has been well tested in the Magellan environment, and it is intended that the SCVDR be designed in such a way as to maximize the inheritance available. The contributions of Peter Ford of MIT, both toward formatting the SCVDR and in preparing this document, are particularly appreciated. Readers may recognize large blocks of text that have been adapted here from the ARCDR SIS with little change. In those sections and elsewhere, however, any errors in the description of the SCVDR product should be attributed solely to this document's Stanford authors.

CHAPTER 2

INTERFACE CHARACTERISTICS

2.1. Hardware Characteristics and Limitations

2.1.1. Special Equipment and Device Interfaces

The SCVDR data are stored on 8 mm cartridge tapes using the UNIX tar (tape archiver) utility.

Original SCVDR products are written in IEEE or VAX binary format using a workstation at Stanford. SCVDR product tapes delivered to DMAT are copies of the original tape(s), with formats as selected by eventual end users (see Distribution page to this document). If additional copies of the SCVDR are requested from Stanford, they will be generated from these original copies.

2.1.2. Special Setup Requirements

None.

2.2. Volume and Size

The SCVDR data for each orbit consist of a set of six files, as detailed in Section 4. The altimetry, image, and emissivity files vary in length according to the characteristics of the spacecraft orbit at the time of data acquisition and with spacecraft system functions and telemetry quality. A typical set of six files from an early orbit in the Magellan Mission comprises 10 MBytes. Each SCVDR product tape contains data from a maximum of 100 orbits.

2.3. Labeling and Identification

2.3.1. Magnetic Label

N/A

2.3.2. External Tape Label

Each volume has an external label defining its contents. The label includes the following structure as the unique product identifier:

```
SCVDR.first-last;version
PROCESS_TIME=YYYY-MM-DDThh:mm:ss.fff
DATA_FORMAT_TYPE=cccc
```

where `first´ and `last´ are 5-digit decimal numbers denoting, respectively, the Project assigned orbit numbers of the first and last orbit contributing data to the product tape. `Version´ is a decimal version number which is initialized at `1´ for each product tape and incremented by 1 for each subsequent iteration of that product tape. For test tapes, `version´ consists of the single character `T´ followed by a decimal number which is initialized at `1´ for each test tape and incremented by 1 for each subsequent iteration of that test tape.

The external label also shows the product creation time (PROCESS_TIME in Section 5.2; see also Section 1.5.4.2) and the binary format (DATA_FORMAT_TYPE in Section 5.2; see also Section 2.1.1).

2.4. Interface Medium Characteristics

SCVDR products are contained on 8 mm cartridge magnetic tapes.

2.5. Failure Protection, Detection, and Recovery Procedures

None.

2.6. End-of-File Conventions

End of file labeling complies with SFDU standards (see Section 4).

2.7. End-of-Volume Conventions

End of volume labeling complies with SFDU standards (see Section 4).

CHAPTER 3

ACCESS

3.1. Programs Using the Interface

Data contained on an SCVDR tape will be accessed by programs at the home institutions of Magellan and other investigators. Those programs cannot be identified here.

It is anticipated that the SCVDR will be a primary input to the creation of the Global Vector Data Record (GVDR) product at Stanford. The GVDR creation process has not yet been defined.

3.2. Synchronization Considerations

3.2.1. Timing and Sequencing Considerations

Data in the altimetry, image, and emissivity files are arranged by "footprint" number, starting from 1. Footprint spacing is a function of altitude and Doppler resolution, but increasing footprint numbers always indicate increasing SCET measurement times.

3.2.2. Effective Duration

Except for test versions, SCVDR product tapes delivered to DMAT are the final versions. That does not preclude reissuance of an SCVDR if subsequent corrections and/or updates justify such action.

3.2.3. Priority Interrupts

None.

3.3. Input/Output Protocols, Calling Sequences

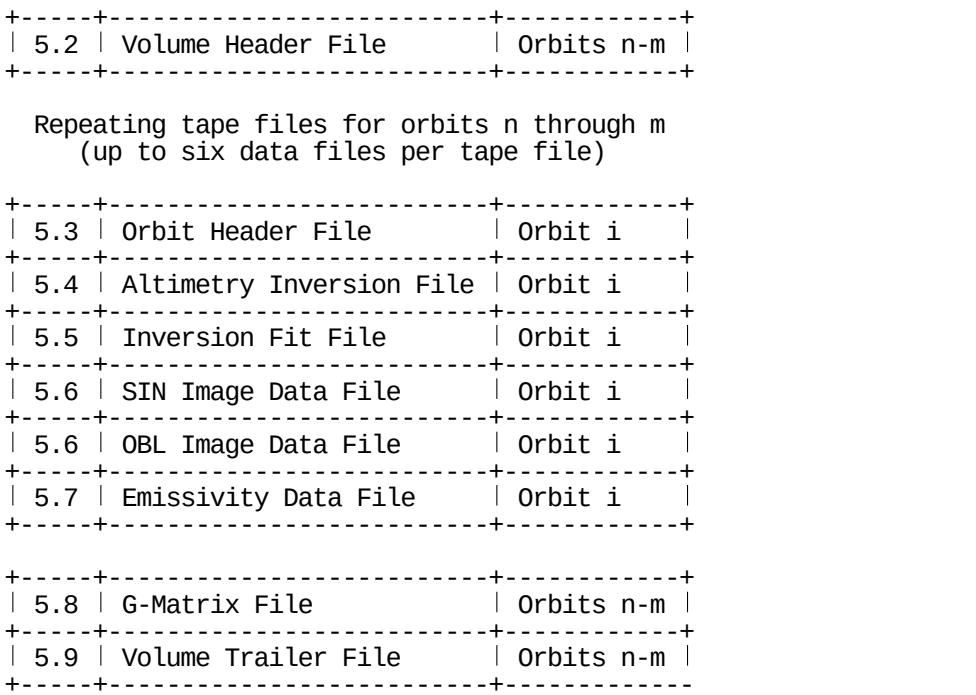
None.

CHAPTER 4

Detailed Interface Specifications

4.1. Structure and Organization Overview

The SCVDR consists of a series of UNIX tar files on 8 mm cartridge tape. The first tar file contains the SCVDR Volume Header File. The next-to-last and last tar files contain, respectively, the SCVDR G-Matrix File and the SCVDR Volume Trailer File. Between the first and next-to-last tar files are tar files (one per Magellan orbit for up to 100 orbits) which contain results of Stanford analyses of Magellan data. In the following diagram the numbers on the left refer to the parts of Section 5 that describe the detailed format of these files.



If neither ALT-EDR nor C-BIDR is available for a particular orbit, the entire set of orbit files are omitted from the SCVDR tape. The omission will be noted in the Catalog/Keyword Label of the Volume Header File. If either the ALT-EDR or C-BIDR (but not both) is missing or unusable, the corresponding data file(s) is recorded, but the SFDU header label is followed by zero logical data records.

4.2. Substructure Definition and Format

Section 5 of this document details the use of Standard Formatted Data Unit (SFDU) labels and headers and provides a description of the data files on the tape. The G-Matrix File is described in Section 5.8; the Volume Header and Trailer Files are detailed in Sections 5.2 and 5.9, respectively.

4.2.1. SFDU Labels and Headers

SFDU labels [5] are used to identify and characterize each file on the product tapes. To conform with the convention adopted for other Magellan data products, all length fields in SFDU labels are recorded as 8-byte ASCII values.

4.2.2. Data Physical Blocking

SCVDR tapes are constructed using the UNIX tar utility. The first tar operation writes the Volume Header File to tape. Subsequent tar operations write data for specific orbits to tape. Data for the ith orbit will be in a later file than data from the j'th orbit if i>j. The next to last tar operation writes the G Matrix File to tape. The final tar operation writes the Volume Trailer File to tape. If there are k orbits of data in the SCVDR, the tape will contain k+3 tar files.

Only default settings are used for the tar operations. The tar operation writes one tar header block to tape, one or more blocks containing file data, and two blocks filled with zeros. Blocks contain 512 bytes each and are typically handled in groups of 20. System default conventions for padding unused space in blocks are used.

Within the tar files, logical records span blocks. Each logical record begins with an SFDU header label. Therefore, file blocks, except the first following the tar header block, do not necessarily begin with SFDU headers.

4.2.3. Block Length

Default block length of 512 bytes is used.

CHAPTER 5

SCVDR Data Block Format Descriptions

5.1. SFDU Label Structures

Each data file contains a series of Standard Formatted Data Units (SFDU's). Each SFDU begins with a 12-byte type header, followed by an 8-byte length indicator, and a varying-length value field. The SCVDR uses several SFDU types:

Primary Label
A string beginning `CCSD1Z´, identifying the data as obeying the conventions of the CCSDS authority.

Catalog/Keyword Label
A string beginning `NJPL1K´ that further identifies each data file by a series of `KEYWORD=VALUE´ definitions.

Data Aggregate
A string beginning `NJPL1I´ that begins a fixed-length block of data.

Aggregation Marker
A pair of strings beginning `CCSD1R´ that sandwiches collections of data with length that is otherwise undefined.

5.1.1. Data File Nomenclature

Names and abbreviations for data files are shown in Table 5-1.

Table 5-1. Data File Nomenclature

SCVDR Product File Name	Abbrev-iation	Data Object or Product Type SFDU Keyword Value
Volume Header File	VHF	
Orbit Header File	OHF	'ORBIT HEADER FILE'
Altimetry Inversion File	ANF	'INVERSION FILE'
Inversion Fit File	NNF	'INV FIT FILE'
SIN Image File	SIF	'SIN IMAGE FILE'
OBL Image File	OIF	'OBL IMAGE FILE'
Emissivity Data File	EDF	'EMISSIVITY FILE'
G-Matrix File	GMF	'G MATRIX FILE'
Volume Trailer File	VTF	

5.1.2. Generic Data File Structure

The generic structure of data files is shown in Figure 5-1. It begins with a 12-byte `CCSD1Z000001´ type field and an 8-byte length field. These are followed by a keyword and value SFDU, a header data SFDU, and a collection of data SFDUs.

Figure 5-1. Sample Varying-Length File Structure

T		CCSD1Z000001	CCSDS label	CCSDS Header
L		00000xxx	Length Field	
V	T	NJPL1K00KL00	K-Label	Keyword and Value SFDU
	L	00000xxx	Length Field	
	V	Catalog and Keyword Information	Keywords and Values	
	T	NJPL1I00TBDH	I-Label	Header SFDU
	L	00000xxx	Length Field	
	V	Data Fields for Header Record	Header Record Data	
	T	CCSD1R000003	Start Label	Aggr Start Marker
	L	00000xxx	Length Field	
	V	DELIMITER=SMARKER PRODUCT_NAME=cccccccc TYPE=NJPL1I00TBDD	Start Value	
	T	NJPL1I00TBDd	I-Label	Data SFDUs (Many)
	L	00000xxx	Length Field	
	V	Data Fields for Data Records	Data	
	T	NJPL1I00TBDd	I-Label	
	L	00000xxx	Length Field	
	V	Data Fields for Data Records	Data	
	...	...		
	T	CCSD1R000003	End Label	Aggr End Marker
	L	000000xx	Length Field	
	V	DELIMITER=EMARKER PRODUCT_NAME=cccccccc	End Value	

When the collection of data SFDUs has variable length (for example, the altimetry, image, emissivity, and G-matrix files), the collection of data SFDU's is bounded by a pair of SFDU "R" labels that identify the start and end of that collection. These labels start with the string `CCSD1R000003´, as shown in Figure 5-1. The keywords `DELIMITER´ and `PRODUCT_NAME´ have the values shown in the following figures. When the bounded data contain more than a single registered SFDU aggregate, the additional "R" label keyword `TYPE´ must be used to describe the data format.

If "R" labels bound varying length data, the length recorded in the primary `CCSD1Z´ label is the length of the catalog/keyword SFDU, plus the length of the header data SFDU, plus the length of the first "R" label SFDU. Otherwise, the length recorded in the primary label is that of the remainder of the file, i.e. 20 less than the total number of bytes in the data file.

Sections 5.2 through 5.9 describe specific data file and record structures in detail. Section 5.1.3 describes the generic keyword and label SFDU.

5.1.3. Generic Catalog Keyword Labels

The SFDU catalog keyword label is made up of a set of fields that completely identify each file according to its type, content, origin, and version. In addition, the label contains time tags identifying the time and date on which the data were created.

The value of the catalog keyword label is an ASCII string comprising several keyword/value pairs. Alphanumeric characters are always in UPPERCASE. Underscore characters (0x5f) are used between words—no "white spaces" such as null (0x0), space[1] (0x20), or tab (0x9) are permitted. All numeric fields are of fixed length, and unused leading digit positions are filled with ASCII zero (`0´) characters.

The "keyword=value" syntax used in SCVDR keyword labels is a subset of the "Object Definition Language" (ODL) used by the Planetary Data System [6]. Each keyword/value pair is separated by an equals sign and is terminated by a carriage return (0xd) followed by a line feed (0xa), which are not shown in the following figures. Figure 5-2 identifies some of the parameters that will appear in SCVDR keyword fields.

Figure 5-2. Sample SCVDR Catalog/Keyword Label

T	NJPL1K00KL00	K-Label
L	00000xxx	Length Field
V	DATE_SET_NAME=SCVDR.nnnnn-nnnnn.v	Keywords and Values
	DATA_OBJECT_TYPE=SCVDR	
	PRODUCT_SEQUENCE_NUMBER=nnnnn	
	PRODUCT_FILE_NAME=cccccccc	
	PRODUCT_TYPE=cccccccc	
	MISSION_ID=4	
	MISSION_NAME=MAGELLAN	
	SPACECRAFT_ID=18	
	SPACECRAFT_NAME=MAGELLAN	
	ORBIT_NUMBER=nnnnn	
	UPLOAD_ID=ccccc	
	NAV_UNIQUE_ID=cccccc	
	HARDWARE_VERSION_ID=nnn	
	MAJOR_SOFTWARE_VERSION_ID=nnn	
	MINOR_SOFTWARE_VERSION_ID=nnn	
	PROCESS_TIME=YYYY-MM-DDThh:mm:ss.fff	
	DATA_FORMAT_TYPE=cccc	

[1] Catalog keyword headers must contain an even number of bytes. To accomplish this, an ASCII blank (0x20) may be added before the last carriage return and line feed. Subsequent data then line up on even-numbered boundaries.

K-Label `NJPL1K00KL00´, the SFDU Catalog/Keyword label, where `1´ indicates that an ASCII length field follows. The `KL00´ sub-field indicates that the keywords follow ODL syntax.

Length Field Eight bytes, ASCII, with leading zeroes mandatory; the length of the value field, including two bytes per keyword/value pair for the (unillustrated) carriage return and line feed, and a possible trailing blank if required to make this length an even number.

Keywords and Values

DATA_SET_NAME= The unique product identifier from the external label (Section 2.3.2) in the format `SCVDR.first-last.version´. This keyword appears only in the Volume Header File.

DATA_OBJECT_TYPE= Always `SCVDR´. The intention is that the value of the keyword `DATA_SET_NAME=´ should be unique within all instances of the `DATA_OBJECT_TYPE=´. This keyword only appears in the Volume Header File.

PRODUCT_SEQUENCE_NUMBER= A 5-character numeric string, with leading zeroes, that is incremented by 1 for each SCVDR product. The first will be numbered `00001´. SCVDR products with identical sequence numbers can be assumed to be identical. This keyword appears only in the Volume Header File.

PRODUCT_FILE_NAME= The unique file name that identifies a data file. This keyword does not appear in the Volume Header or Trailer files. For other files the names are of the form

OHFnnnnn.v
ANFnnnnn.v
NFFnnnnn.v
SIFnnnnn.v
OIFnnnnn.v
EDFnnnnn.v
GMFnnnnn.v

where prefixes are as shown in Table 5-1, `nnnnn´ indicates the orbit number (or first orbit number in the case of the G-Matrix File), and `v´ denotes the version number of the file.

PRODUCT_TYPE= The type of the data file, which takes on one of the values listed in the third column of Table 5-1. This keyword does not appear in the Volume Header or Trailer Files.

MISSION_ID= The single character `4´.

MISSION_NAME= The character string `MAGELLAN´.

SPACECRAFT_ID= For real data, the two-digit number `18´. For simulated data, the number `28´.

SPACECRAFT_NAME= The character string `MAGELLAN´.

ORBIT_NUMBER= A five-digit integer with leading zeroes, identifying the orbit from which this data set was generated. Multiple orbit numbers are used only in the Volume Header File label, where they are separated by commas and enclosed in parentheses, i.e. `(nnnnn,nnnnn,...)´. The list of multiple orbit numbers denotes the order of Magellan orbit numbers of the data files contained in this product. Orbits begin at apoapsis. The numbers are the same as those used on the corresponding ALT-EDR and C-BIDR input tapes.

UPLOAD_ID=	Six characters `PBBBBC´, where `P´ is the mission phase, `BBBB´ is the upload number within that phase, and `C´ is a revision indicator in the range A-Z
NAV_UNIQUE_ID=	A character string indicating the orbit solution used in the ephemeris file(s) for processing. NB: orbit solutions may be different for altimetry and image data processing; for all of Magellan Cycle 1 and much of Cycle 2, only a single NAV_UNIQUE_ID was available during construction of the SCVDR.
HARDWARE_VERSION_ID=	A 3-digit number, `nnn´, identifying the hardware version number of the Stanford data processing system used to create this SCVDR file or volume.
MAJOR_SOFTWARE_VERSION_ID=	A 3-digit number, `nnn´, identifying the major software version number of the Stanford SCVDR program used to create this file or volume.
MINOR_SOFTWARE_VERSION_ID=	A 3-digit number, `nnn´, identifying the minor software version number of the Stanford SCVDR program used to create this file or volume.
PROCESS_TIME=	Indicates the time (UTC) at which the product was created or substantially modified. See Section 1.5.4.2 for format. For the Volume Header File this is the time which appears on the external label (Section 2.3.2).
DATA_FORMAT_TYPE=	Either `VAXX´ or `IEEE´, depending on the format in which binary fields are represented in the data records. This is the format which appears on the external label (Section 2.3.2).

5.2. Volume Header File

Each SCVDR product tape begins with a Volume Header File (VHF)-a set of SFDU volume descriptors and catalog keywords. It identifies the number and sequence of orbits on this multi-orbit product. Compared with the generic data file structure (Section 5.1.2) the Volume Header File contains only the CCSD header, the keyword and value SFDU, and the aggregation start marker. The corresponding aggregation end marker is contained in the Volume Trailer File.

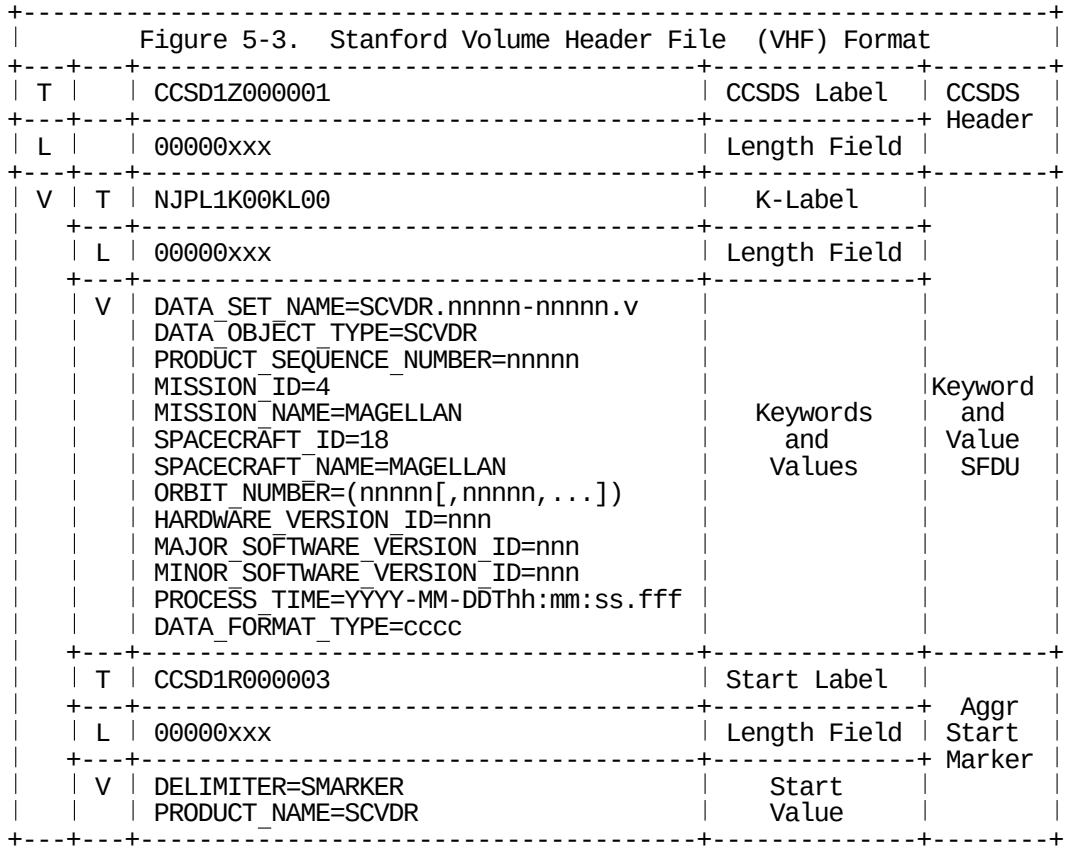


Figure 5-3. Stanford Volume Header File (VHF) Format

CCSDS Label `CCSD1Z000001´, the CCSDS primary SFDU label.

Length Field Eight bytes, ASCII, with leading zeroes mandatory; the length of the remainder of the Volume Header File.

Keyword and Value SFDU See Section 5.1.3.

Aggregation Start Marker

Start Label `CCSD1R000003´, the SFDU Aggregation Marker label, indicating the start of a data aggregation of unspecified length. This aggregation consists of the remainder of the product, and is matched by an ending marker in the Volume Trailer File.

Length Field Eight bytes, ASCII, with leading zeroes mandatory; the length of the remainder of the aggregation marker SFDU.

Start Value

`DELIMITER=` The character string `SMARKER´, indicating that this is the start of a data aggregation.

`PRODUCT_NAME=` The character string `SCVDR´.

5.3. Orbit Header File

Each Orbit Header File (OHF) identifies the orbit number, time frame, and orbital geometry for one Magellan orbit. The file format is illustrated in Figure 5-4. Compared with the generic data file structure (Section 5.1.2) the OHF contains only the CCSD header, the keyword and value SFDU, and the header record SFDU. The OHF header record block is depicted in Table 5-2 and has a fixed length of 280 bytes.

Figure 5-4. Stanford Orbit Header File (OHF) - Block Format

T		CCSD1Z000001	CCSDS Label	CCSDS Header
L		00000xxx	Length Field	
V	T	NJPL1K00KL00	K-Label	
	L	00000xxx	Length Field	
	V	PRODUCT_FILE_NAME=OHFnnnnn.v	Keywords and Values	Keyword and Value SFDU
		PRODUCT_TYPE=ORBIT_HEADER_FILE		
		MISSION_ID=4		
		MISSION_NAME=MAGELLAN		
		SPACECRAFT_ID=18		
		SPACECRAFT_NAME=MAGELLAN		
		ORBIT_NUMBER=nnnnn		
		UPLOAD_ID=cccccc		
		HARDWARE_VERSION_ID=nnn		
		MAJOR_SOFTWARE_VERSION_ID=nnn		
		MINOR_SOFTWARE_VERSION_ID=nnn		
		PROCESS_TIME=YYYY-MM-DDThh:mm:ss.fff		
		DATA_FORMAT_TYPE=cccc		
	T	NJPL1I000004	I-Label	Orbit Header Record (Table 5-2)
	L	00000260	Length Field	
	V	Data Fields for Orbit Header Record		

CCSDS Label `CCSD1Z000001´, the CCSDS primary SFDU label.

Length Field Eight bytes, ASCII, with leading zeroes mandatory; the length of the remainder of the Orbit Header File.

Keyword and Value SFDU See Section 5.1.3.

Orbit Header Record See Table 5-2 and the definitions following it.

Table 5-2. Stanford Orbit Header Record SFDU (hr_rec)

Off	Len	Type	Name	Description (see footnote 2)
+0	20	sfdu	hr_sfdu	SFDU label and length
20	4	ulong	hr_orb	Orbit number
24	4	ulong	hr_ninv	Number of Altimetry Inversion Records
28	4	ulong	hr_nfit	Number of Inversion Fit Records

[2] Data element definitions use the conventions of the C programming language. Refer to appendix A for a bit-level description of field types.

Table 5-2 (contd). Stanford Orbit Header Record SFDU (hr_rec)

32	4	ulong	hr_nismg	Number of SIN Image Data Records
36	4	ulong	hr_niomg	Number of OBL Image Data Records
40	4	ulong	hr_nems	Number of Emissivity Data Records
44	4	uchar	hr_pad1[4]	spares
48	8	double	hr_inv_start	First Inversion Fpt Time (SCET,TDB
56	8	double	hr_inv_end	Last Inversion Fpt Time (SCET,TDB)
64	8	double	hr_fit_start	First Fit Fpt Time (SCET,TDB)
72	8	double	hr_fit_end	Last Fit Fpt Time (SCET,TDB)
80	8	double	hr_simg_start	First SIN Image Fpt Time (SCET,TDB)
88	8	double	hr_simg_end	Last SIN Image Fpt Time (SCET,
96	8	double	hr_oimg_start	First OBL Image Fpt Time (SCET,
104	8	double	hr_oimg_end	Last OBL Image Fpt Time (SCET,
112	8	double	hr_ems_start	First Emissivity Fpt Time (SCET,
120	8	double	hr_ems_end	Last Emissivity Fpt Time (SCET,
128	15	sclk	hr_avg_sclk	Predict Periapsis Time (SCLK fmt [13])
143	23	char	hr_avg_sma	Average Semi-Major Axis (km)
166	23	char	hr_avg_ecc	Average Eccentricity
189	23	char	hr_avg_incl	Average Inclination (deg)
212	23	char	hr_avg_lon	Avg Longitude of Ascending Node (deg)
235	23	char	hr_avg_arg	Average Argument of Periapsis (deg)
258	6	uchar	hr_pad2[6]	spares
264	16	uchar	hr_spare[16]	spares
280				

Element Name	Type	Length	Description
hr_sfdu	sfdu	20	SFDU Label and Length: `NJPL1I00000400000260´. The designator `0004´ is registered with the NJPL SFDU authority as the "Orbit Header Record".

hr_orb	ulong	4	The Magellan Orbit Number corresponding to the following five files (altimetry inversion, inversion fit, sinusoidal image, oblique sinusoidal image, and emissivity). An orbit begins at apoapsis, and the number corresponds to the input data from the corresponding ALT-EDR and/or C-BIDR tape(s).
hr_ninv	ulong	4	Number of Altimetry Inversion Records—the number of nr_rec SFDU's in this orbit's Altimetry Inversion File.
hr_nfit	ulong	4	Number of Inversion Fit Records—the number of fr_rec SFDU's in this orbit's Inversion Fit File. fr_nrec and nr_nrec should be the same.
hr_nsimg	ulong	4	Number of Sinusoidal Equal Area Image Data Records—the number of ir_rec SFDU's in this orbit's Sinusoidal Image Data File.
hr_noimg	ulong	4	Number of Oblique Sinusoidal Equal Area Image Data Records—the number of ir_rec SFDU's in this orbit's Oblique Image Data File.
hr_nems	ulong	4	Number of Emissivity Data Records—the number of er_rec SFDU's in this orbit's Emissivity Data File.
hr_pad1[4]	uchar	4	spares
hr_inv_start	double	8	First Inversion Footprint Time (SCET)—the S/C ephemeris time (seconds of TDB since J2000. see Section 1.5.4.2) that represents the first altimeter inversion footprint of this orbit. It is equal to the nr_scet value in the first nr_rec record of this orbit's Altimetry Inversion File.
hr_inv_end	double	8	Last Inversion Footprint Time (SCET)—the S/C ephemeris time (seconds of TDB since J2000. see Section 1.5.4.2) that represents the last altimeter inversion footprint of this orbit. It is equal to the nr_scet value in the last nr_rec record of this orbit's Altimetry Inversion File.
hr_fit_start	double	8	First Inversion Fit Footprint Time (SCET)—the S/C ephemeris time (seconds of TDB since J2000. see Section 1.5.4.2) that represents the first inversion fit footprint of this orbit. It is equal to the nr_scet value in the first nr_rec record of this orbit's Altimetry Inversion File.
hr_fit_end	double	8	Last Inversion Fit Footprint Time (SCET)—the S/C ephemeris time (seconds of TDB since J2000. see Section 1.5.4.2) that represents the last inversion fit footprint of this orbit. It is equal to the nr_scet value in the last nr_rec record of this orbit's Altimetry Inversion File.
hr_simg_start	double	8	First SIN Image Footprint Time (SCET)—the S/C ephemeris time (seconds of TDB since J2000. see Section 1.5.4.2) that represents the first sinusoidal image footprint of this orbit. It is equal to the ir_scet value in the first ir_rec record of this orbit's sinusoidal image data file.

hr_simg_end	double	8	Last SIN Image Footprint Time (SCET)—the S/C ephemeris time (seconds of TDB since J2000. see Section 1.5.4.2) that represents the last sinusoidal image footprint of this orbit. It is equal to the ir_scet value in the last ir_rec record of this orbit's sinusoidal image data file.
hr_oimg_start	double	8	First OBL Image Footprint Time (SCET)—the S/C ephemeris time (seconds of TDB since J2000. see Section 1.5.4.2) that represents the first oblique image footprint of this orbit. It is equal to the ir_scet value in the first ir_rec record of this orbit's oblique image data file.
hr_oimg_end	double	8	Last OBL Image Footprint Time (SCET)—the S/C ephemeris time (seconds of TDB since J2000. see Section 1.5.4.2) that represents the last oblique image footprint of this orbit. It is equal to the ir_scet value in the last ir_rec record of this orbit's oblique image data file.
hr_ems_start	double	8	First Emissivity Footprint Time (SCET)—the S/C ephemeris time (seconds of TDB since J2000. see Section 1.5.4.2) of the first emissivity measurement of this orbit. It is equal to the er_scet value in the first er_rec record of this orbit's emissivity data file.
hr_ems_end	double	8	Last Emissivity Footprint Time (SCET)—the S/C ephemeris time (seconds of TDB since J2000. see Section 1.5.4.2) of the last emissivity measurement of this orbit. It is equal to the er_scet value in the last er_rec record of this orbit's emissivity data file.
hr_avg_sclk	sclk	15	Predicted Periapsis Time (SCLK)—the periapsis time of the predicted orbit in spacecraft clock units (see [13] for details on SCLK format).
hr_avg_sma	char	23	Semi-Major Axis (km)—the semi-major axis of the predicted orbit[3].
hr_avg_ecc	char	23	Eccentricity—the eccentricity of the predicted orbit[3].
hr_avg_incl	char	23	Inclination (degrees)—the inclination of the predicted orbit[3] with respect to the xy-plane of the J2000 coordinate system.
hr_avg_lon	char	23	Longitude of Ascending Node (degrees)—the angle in the xy-plane of the J2000 coordinate system to the ascending node of the predicted orbit[3].
hr_avg_arg	char	23	Argument of Periapsis (degrees)—the angle in the plane of the predicted orbit[3] from the ascending node in the xy-plane of the J2000 coordinate system to the periapsis.
hr_pad2[6]	uchar	6	spares
hr_spare[16]	uchar	16	spares

[3] The ''predicted'' orbit is based on the elements used to generate the uplink commands for the current mapping pass. It represents an average over the entire orbit, and is **not** the result of post-orbit navigation solutions. The elements should be used for comparison purposes only, since they may involve large errors. The predicted orbit elements are copied from the orbit header file of the ALT-EDR tape, or, if unavailable, from the orbit header of the C-BIDR.

5.4. Altimetry Inversion File

Figure 5-5. Stanford Altimetry Inversion File (ANF) - Block Format

T		CCSD1Z000001	CCSDS Label	CCSDS Header
L		00000xxx	Length Field	
V	T	NJPL1K00KL00	K-Label	
	L	00000xxx	Length Field	
	V	PRODUCT_FILE_NAME=ANFnnnnn.v PRODUCT_TYPE=INVERSION_FILE MISSION_ID=4 MISSION_NAME=MAGELLAN SPACECRAFT_ID=18 SPACECRAFT_NAME=MAGELLAN ORBIT_NUMBER=nnnnn UPLOAD_ID=cccccc NAV_UNIQUE_ID=cccccc HARDWARE_VERSION_ID=nnn MAJOR_SOFTWARE_VERSION_ID=nnn MINOR_SOFTWARE_VERSION_ID=nnn PROCESS_TIME=YYYY-MM-DDThh:mm:ss.fff DATA_FORMAT_TYPE=cccc	Keywords and Values	Keyword and Value SFDU
	T	NJPL1I000005	I-Label	ALT Inver Header SFDU (Table 5-3)
	L	00000xxx	Length Field	
	V	Data Fields for Altimetry Inversion Header Record		
	T	CCSD1R000003	Start Label	Aggr Start Marker
	L	000000xx	Length Field	
	V	DELIMITER=SMARKER PRODUCT_NAME=ALTIMETRY_INVERSION TYPE=NJPL1I000025	Start Value	
	T	NJPL1I000006	I-Label	ALT Inver Record (Table 5-4)
	L	00000xxx	Length Field	
	V	Altimetry Inversion Data Records	Data	
	T	CCSD1R000003	End Label	Aggr End Marker
	L	000000xx	Length Field	
	V	DELIMITER=EMARKER PRODUCT_NAME=ALTIMETRY_INVERSION	End Value	

CCSDS Label `CCSD1Z000001´, the CCSDS primary SFDU label.

Length Field Eight bytes, ASCII, with leading zeroes mandatory; the length of the remainder of the Altimetry Inversion File header.

Keyword and Value SFDU See Section 5.1.3.

Inversion Header Record	See Table 5-3.
Aggregation Start Marker	
Start Label	`CCSD1R000003´, the SFDU Aggregation Marker label, indicating the start of a data aggregation of unspecified length. This aggregation consists of a varying number of Altimetry Inversion Record SFDU's (nr_rec), as shown in Table 5-4.
Length Field	Eight bytes, ASCII, with leading zeroes mandatory; the length of the remainder of the aggregation marker SFDU.
Start Value	
DELIMITER=	The character string `SMARKER´, indicating that this is the start of a data aggregation.
PRODUCT_NAME=	The character string `ALTIMETRY_INVERSION´.
TYPE=	The character string `NJPL1I000025´, where `0025´ indicates that the data between the SMARKER and EMARKER labels comprise a registered SFDU aggregation (the Altimetry Inversion Aggregate), composed of a set of registered NJPL aggregates.
Altimetry Inversion Record	See Table 5-4.
Aggregation End Marker	
End Label	`CCSD1R000003´, the SFDU Aggregation Marker label, indicating the end of a data aggregation of unspecified length. This matches the above "Start Marker".
Length Field	Eight bytes, ASCII, with leading zeroes mandatory; the length of the remainder of the aggregation marker SFDU.
End Value	
DELIMITER=	The character string `EMARKER´, indicating that this is the end of a data aggregation.
PRODUCT_NAME=	The character string `ALTIMETRY_INVERSION´.

5.4.1. Altimetry Inversion Header Record

Table 5-3. Stanford Altimetry Inversion Header Record SFDU (nh_rec)

Off	Len	Type	Name	Description
+0	20	sfdu	nh_sfdu	SFDU label and length
20	4	long	nh_orb	Orbit number
24	4	long	nh_ver	Orbit version
28	2	short	nh_altinv_major	Program ALTINV major version number
30	2	short	nh_altinv_minor	Program ALTINV minor version number
32	2	short	nh_alt_major	Program ALT major version number
34	2	short	nh_alt_minor	Program ALT minor version number
36	1	uchar	nh_cvmf	Covariance matrix flag
37	1	uchar	nh_meth_inv	Inversion method ID
38	1	uchar	nh_meth_sig	Variance estimation method ID
39	1	uchar	nh_meth_Gamsig	Constraint variance method ID
40	1	uchar	nh_meth_thermal	Thermal noise method ID
41	1	uchar	nh_specf	Non-delta spectral filter flag
42	1	uchar	nh_meth_frot	Doppler rotation method ID
43	1	uchar	nh_pad	spare
44	4	long	nh_nrec	Number of data records
48	1	uchar	nh_meth_echo	Range echo processing ID
49	1	uchar	nh_meth_bmax	Maximum angle method ID
50	2	short	nh_hid	Pulse compression ID
52	2	short	nh_comp_major	Comp major version ID
54	2	short	nh_comp_minor	Comp minor version ID
56	2	short	nh_maxB	Maximum size of scattering function
58	2	short	nh_maxN	Maximum size of covariance matrix
60	12	uchar	nh_spare[12]	spares
+72				

Element Name	Type	Length	Description
nh_orb	long	4	Orbit Number-the Magellan orbit number for the data represented in these data records.
nh_ver	long	4	Orbit version number-the version of the altimetry data file used for these results. Obtained from the VERSION_ID keyword of the corresponding ALT-EDR Orbit Header File (NB: This turns out **not** to be a good indicator of the version of the data file; the Orbit Header File itself is rarely updated).
nh_altinv_major	short	2	Program ALTINV Major Version Number-the major software version number of the Stanford program ALTINV used to obtain the scattering function solution.
nh_altinv_minor	short	2	Program ALTINV Minor Version Number-the minor software version number of the Stanford program ALTINV used to obtain the scattering function solution.
nh_alt_major	short	2	Program ALT Major Version Number-the major software version number of the Stanford program ALT used to compute the range-Doppler array from the raw altimetry data.
nh_alt_minor	short	2	Program ALT Minor Version Number-the minor software version number of the Stanford program ALT used to compute the range-Doppler array from the raw altimetry data.
nh_cvmf	uchar	1	Covariance Matrix Flag-if set (1) the upper triangular portion (in row-major order) of the covariance matrix is saved in nr_cvm; if not set (0), only the diagonal is saved.
nh_meth_inv	uchar	1	Inversion Method ID-code number for the specific method of over-determined least squares used to compute the inversions. Possible values are: 0 Singular Value Decomposition (preferred) 1 QR Decomposition
nh_meth_sig	uchar	1	Variance Estimation Method ID-code number for the method used to estimate the statistical uncertainty in the input data. The resulting variance is used in a weighted least squares fit and propagated to form an estimate of the inverted uncertainty in the solution. Possible values are: 0 Use Doppler spectrum and range echo after averaging bursts and summing across range and Doppler. 1 Use full range-Doppler map before averaging and summing (preferred). 2 Use the sample variance of the data itself, rather than a priori assumptions about the observation error distributions. 3 Do not estimate the variance: weight each observation equally.

nh_meth_Gamsig	uchar	1	Constraint Variance Method ID-code number for the method used to assign weight to the smoothing constraint that controls the shape of the inversion. Determines the scale of smoothing parameter nr_gamma. Possible values are: 0 Use the mean of the observed data. 1 Use the value 1. 2 Use a value that causes the smoothing matrix and model matrix to contribute equally to the error criterion when nr_gamma is 1, and in proportion to nr_gamma otherwise. This depends on the variance of the observations (preferred).
nh_meth_thermal	uchar	1	Thermal Noise Method ID-code number for the method used to account for the effects of thermal noise on the observations. Possible values are: 0 Ignore effects of thermal noise. 1 Before the inversion, subtract an estimate of the thermal noise from the observations. 2 Solve for the thermal noise in the inversion itself (preferred).
nh_specf	uchar	1	Non-Delta Spectral Filter Flag-if set (1), the Doppler spectrum has been convolved with an FIR filter before the inversion process. The nominal filter is [0.25 0.50 0.25] but is not saved in the SCVDR. If not set (0), no filter has been used (preferred).
nh_meth_frot	uchar	1	Doppler Rotation Method ID-code number for the method used to account for unexpected Doppler shifts in the observed echo spectrum. Possible values are: 0 Ignore any shift. 1 Compute three inversions, with the Doppler spectrum rotated by –1, 0, and +1 bins of 935 Hz, and choose the rotation that gives the smallest residual error. 2 Compute the centroid of the Doppler spectrum, compute two inversions with the spectrum rotated an integer number of bins just less than and just greater than the centroid, and choose the rotation that gives the smaller residual error (preferred).
nh_pad	uchar	1	spare
nh_nrec	long	4	Number of Data Records-the number of altimetry inversion records that follow this header. See Table 5-4.
nh_meth_echo	uchar	1	Range Echo Processing ID-code number for the method used to process the range echo before the inversion. Possible values are: 0 Do not change range echo (preferred). 1 Filter the range echo with an FIR filter, nominally [0.25 0.5 0.25].
nh_meth_bmax	uchar	1	Maximum Angle Method ID-code number for the method used to determine the maximum solution angle in the inversion. Possible values are:

			0 Use an empirically derived table indexed by true anomaly (preferred). 1 Choose the largest angle that avoids the effects of range aliasing for the given geometry.
nh_hid	short	2	Pulse Compression ID-code number for the correlation kernel used in the radar pulse compression stage, before the range-Doppler array is computed. Possible values are: 0 Use the "optimal" code ([11], pages 109-110) (preferred). 1 Use the transmitted range code ([11], page 108).
nh_comp_major	short	2	COMP major version ID-major version number of the Stanford calibration software COMP [9] used to compensate the input data for amplitude and timing effects.
nh_comp_minor	short	2	COMP minor version ID-minor version number of the Stanford calibration software COMP [9] used to compensate the input data for amplitude and timing effects.
nh_maxB	short	2	Maximum size of scattering function-the largest number of elements that will appear in any scattering function (nr_sig0) in this orbit, equal to the largest value of nr_blen. The maximum size in bytes is thus 4*nh_maxB.
nh_maxN	short	2	Maximum size of covariance matrix-the largest number of elements that will appear in any covariance matrix (nr_cvm) in this orbit, equal to the largest value of nr_ncvm. The maximum size in bytes is thus 4*nh_maxN.
nh_spare[12]	uchar	12	spares

5.4.2. Altimetry Inversion Data Record

The Altimetry Inversion Data Record SFDU is specified in Table 5-4.

Table 5-4. Stanford Altimetry Inversion Data Record SFDU (nr_rec)

Off	Len	Type	Name	Description
+0	20	sfdu	nr_sfdu	SFDU label and length
20	4	ulong	nr_nfoot	Footprint number
24	4	ulong	nr_burst	Burst number for associated ALT burst
28	4	ulong	nr_flags	Flag fields (see Table 5-5a)
32	8	double	nr_scet	Footprint time (SCET, TDB)
40	8	double	nr_gdopp	Gross (radial) Doppler shift (Hz)
48	3*8	double	nr_scpos[3]	Spacecraft position (km, J2000)
72	3*8	double	nr_scvel[3]	Spacecraft velocity (km/sec, J2000)
96	3*8	double	nr_sspos[3]	Position of sub-spacecraft point (km, J2000)
120	3*8	double	nr_alta[3]	ALT antenna boresight vector (J2000)
144	3*8	double	nr_sara[3]	SAR antenna boresight vector (J2000)
168	8	double	nr_rt0	Round-trip time for bin 0 (secs)
176	8	double	nr_rpk	Position of range peak within echo
184	4	float	nr_lat	Latitude of nadir (degrees N, VBF85)
188	4	float	nr_lon	Longitude of nadir (degrees E, VBF85)
192	4	float	nr_xfoot	Along-track footprint dimension (km)
196	4	float	nr_yfoot	Cross-track footprint dimension (km)
200	4	float	nr_pvrad	Pioneer-Venus radius at nadir (km)
204	4	ulong	nr_blo	First ALT burst used
208	4	ulong	nr_bhi	Last ALT burst used
212	2	ushort	nr_bav	Number of bursts averaged
214	2	ushort	nr_Gnum	G-matrix ID
216	2	ushort	nr_blen	Number of incidence angles in soln.
218	2	ushort	nr_ncvm	Number of elements saved in nr_cvm
220	4	float	nr_gamma	Smoothing factor
224	4	float	nr_chisq	Chi-square residual from solution

Table 5-4 (contd). Stanford Altimetry Inversion Data Record SFDU (nr_rec)				
228	4	float	nr_rmss	RMS surface slope from data (radians)
232	36	thn t	nr_thn	Thermal noise estimates
268	4	float	nr_dcent	Doppler centroid (Hz)
272	4	float	nr_dcentv	Estimated variance of nr_dcent(Hz**2)
276	4	float	nr_frot	Doppler rotation in solution (Hz)
280	52	calib_t	nr_calib	Calibration details
332	54	sab_hdr_t	nr_SAB	SAB header
386	2	uchar	nr_pad[2]	spares
388	16	uchar	nr_spare[16]	spares
404	p	float	nr_sig0[n]	Scattering function solution, n=nr_blen, p=4n
404+p	p	float	nr_ang[n]	Angle vector corresponding to nr_sig0, q=2p
404+q	4*m	float	nr_cvm[m]	Covariance matrix for nr_sig0, m=nr_ncvm
N	N=404+q+4*m			

Element Name	Type	Length	Description
nr_sfdu	sfdu	20	SFDU Header Label and Length: `NJPL1I0000060000nnnn´. The number `0006´ is registered with the NJPL SFDU authority as the "Altimetry Inversion Data Record."
nr_nfoot	ulong	4	Footprint Number—starting from 1, the number of the Altimetry Inversion Record by increasing Altimetry Footprint Time (nr_scet).
nr_burst	ulong	4	Burst Number—the logical record number from the ALT-EDR burst SFDU most closely associated with this footprint. If the number of bursts averaged (nr_bav) is odd, the middle burst; if nr_bav is even, the earlier of the two middle bursts.
nr_flags	ulong	4	Flag fields—see Table 5-5a.
nr_scet	double	8	Footprint Time (SCET)—the burst start time (seconds of TDB since J2000; see Section 1.5.4.2) for the burst given by nr_burst.
nr_gdopp	double	8	Gross Doppler Shift (Hz)—the Doppler shift resulting from motion of the spacecraft toward nadir at nr_scet. (nr_gdopp>0 means the spacecraft altitude is decreasing).

nr_scpos[3]	double	3*8	Spacecraft Position Vector (km, J2000)—the spacecraft position at nr_scet, relative to the Venus center of mass, expressed in inertial coordinates.
nr_scvel[3]	double	3*8	Spacecraft Velocity Vector (km sec^{-1}, J2000)—the spacecraft velocity at nr_scet, relative to the Venus center of mass, expressed in inertial coordinates.
nr_sspos[3]	double	3*8	Sub-Spacecraft Position Vector (km, J2000)—the position of the nadir point (on a reference sphere of 6051 km radius) at nr_scet, relative to the Venus center of mass, expressed in inertial coordinates.
nr_alta[3]	double	3*8	Altimetry Antenna Boresight Vector (J2000)—unit vector along the axis of the altimetry antenna at nr_scet, expressed in inertial coordinates.
nr_sara[3]	double	3*8	SAR Antenna Boresight Vector (J2000)—unit vector along the axis of the high-gain (SAR) antenna at nr_scet, expressed in inertial coordinates.
nr_rt0	double	8	Round-Trip Time for Bin 0 (seconds)—the round-trip light time corresponding to the first range bin (before peak detection and rotation) in the averaged altimetry echo at nr_scet.
nr_rpk	double	8	Incremental Round-Trip Time (seconds)—the position of the echo peak with respect to the range bin used in nr_rt0 (each range bin represents an additional 0.442 microseconds of round-trip delay beyond nr_rt0.)
nr_lat	float	4	Latitude of Nadir (degrees N, VBF85)—the body-fixed latitude of the nadir at nr_scet, in the range of –90 (South Pole) to +90 (North Pole); the nominal latitude of the footprint.
nr_lon	float	4	Longitude of Nadir (degrees E, VBF85)—the body-fixed longitude of the nadir at nr_scet, in the range of 0–360. Periapsis nadir increases in longitude by about 1.48 per day (about 0.2 per orbit); the nominal footprint longitude.
nr_xfoot	float	4	Along-Track Altimetry Footprint Dimension (km)—the along-track dimension of the intersection of the 3-dB (two-way) altimetry antenna pattern with the surface when the antenna boresight is aimed at nadir (a very approximate measure of the along-track footprint dimension).
nr_yfoot	float	4	Cross-Track Altimetry Footprint Dimension (km)—the cross-track dimension of the intersection of the 3-dB (two-way) altimetry antenna pattern with the surface when the antenna boresight is aimed at nadir (a very approximate measure of the across-track footprint dimension).
nr_pvrad	float	4	Pioneer-Venus Radius at Nadir (km)—radius of Venus at the nadir point as determined from Pioneer Venus data (provided by MIT in GIPS image format).

nr_blou	long	4	First ALT Burst Used—the number of the first burst included in the average altimetry echo for this record.
nr_bhiu	long	4	Last ALT Burst Used—the number of the last burst included in the average altimetry echo for this record.
nr_bavu	short	2	Number of Bursts Averaged—the total number of altimeter bursts averaged to make this record.
nr_Gnum	ushort	2	G-matrix ID number—identifies the range-Doppler-angle array used to invert the range-Doppler data in this averaged echo (see Section 5.8). G-matrices are indexed from 0.
nr_blen	ushort	2	Number of Incidence Angles in Solution—Number of angle increments in the solution for the scattering function from this average echo.
nr_ncvm	ushort	2	Number of Elements Saved in nr_cvm—the number of covariance values stored in nr_cvm (depends on nh_cvmf; see also nr_cvm). nh_cvmf nr_ncvm 0 nr_blen+1 1 (nr_blen +1)*(nr_blen+2)/2
nr_gamma	float	4	Smoothing Factor—the value of the parameter used to minimize second differences in the scattering function solution for this average echo (see also nr_meth_Gamsig in Section 5.4.1).
nr_chisq	float	4	Chi-Square Residual from Solution—the residual from the weighted least-square error inversion for the scattering function
nr_rmss	float	4	RMS Surface Tilt from Data (radians)—RMS surface tilt θ_0 calculated from the nr_blen points in the solution[4].
nr_thn	thn_t	36	Thermal Noise Estimates (watts per range-Doppler bin)—estimates of thermal noise (and its variance) calculated during the solution for the scattering function (see Table 5-5b).
nr_dcent	float	4	Doppler Centroid (Hz)—the calculated center of the spectrum of the radar receiver signal.
nr_dcentv	float	4	Estimated variance of nr_dcent (Hz^2).

---

[4] $\langle \tan^2\theta_0 \rangle^{1/2} = \left[\sum_{i=1}^{nr_blen} \tan^2\theta_i * p(\theta_i) * \sin\theta_i * \Delta\theta_i \right]^{1/2}$

where $p(\theta) = \frac{2K\sigma_0(\theta)}{\sec\theta}$ and K is found from $\sum_{i=1}^{nr_blen} p(\theta_i) * \sin\theta_i * \Delta\theta_i = 1$

nr_frot	float	4	Doppler Rotation Used for Solution (Hz)—the offset of the echo from its nominal center bin position assumed to be due to surface effects (an integral multiple of 935 Hz, the width of a single frequency bin)(see also nh_meth_frot in Section 5.4.1).
nr_calib	calib_t	52	Calibration Details—the contributing factors to nr_CALT (see Table 5-5c).
nr_SAB	sab_t	54	SAB Header—SAR/Altimetry Burst Header (see Table 5-5d).
nr_pad[2]	uchar	2	spares
nr_spare[16]	uchar	16	spares
nr_sig0[n]	float	4*n	Scattering Function—the so function obtained by inverting the average altimetry radar echo from bursts nr_blo through nr_bhi. The function is a vector of n=nr_blen numbers for the (effective) incidence angles given by nr_ang.
nr_ang[n]	float	4*n	Solution Angles for Scattering Function (radians)—the n=nr_blen angles at which the scattering function solution has been obtained. The default angles are spaced by 0.5 degrees, starting at 0.25—that is, the solution angles are 0.25, 0.75, 1.25, 1.75, ... nr_blen*0.5–0.25 degrees; note, however, that nr_ang is given in radians.
nr_cvm[m]	float	4*m	Covariance Matrix—matrix of estimated covariances of nr_sig0 and nr_thn[0]. The size (m=nr_ncvm) and form of the matrix[5] that is stored depends on the value of nh_cvmf in the Inversion Header Record (see Table 5-3). If nh_cvmf is zero, only the m=nr_blen+1 diagonal entries of the matrix above are stored. If nh_cvmf is nonzero, the upper triangular portion (including the diagonal) are stored in row-major order, for a total of m=(nr_blen+1)*(nr_blen+2)/2 entries.

[5] $E\left\{\begin{bmatrix} nr_thn[0]-\overline{nr_thn[0]} \\ nr_sig0-\overline{nr_sig0} \end{bmatrix}\left[(nr_thn[0]-\overline{nr_thn[0]})(nr_sig0-\overline{nr_sig0})^T\right]\right\}$

where E and $^-$ denote statistical expectation, and nr_sig0 is considered a column vector.

5.4.2.1. Altimetry Inversion Record Flag Values

Table 5-5a. Stanford Altimetry Inversion Record Flag Values (nr_flags)

Name	Value	Description (see footnote 6)
NR_FLAG_NOSIGNAL	1	At least one burst had no signal present, according to telemetered status of transmitter and receiver.
NR_FLAG_GFAR	2	G-matrix was computed for a spacecraft-planet geometry too different from the actual geometry (nominally 1 degree of true anomaly.
NR_FLAG_BSEP	4	Two consecutive bursts were separated by too much distance (nominally 10 km at nadir).
NR_FLAG_BWID	8	The bursts used in the inversion span too much total distance (nominally 50 km at nadir).
NR_FLAG_RPK	16	The echo peak estimate nr_rpk is suspect, and should not be used.

5.4.2.2. Altimetry Inversion Record Thermal Noise Estimates

Table 5-5b. Stanford Altimetry Inversion Thermal Noise Estimates (thn_t)

Off	Len	Type	Name	Description
+0	4	float	tn_sol	Inversion solution
4	4	float	tn_solv	Estimated variance of nr_thnsol
8	4	float	tn_min	Smallest range-Doppler array value
12	4	float	tn_avg	Average of small range-Doppler values
16	4	float	tn_r	Minimum in range echo

Element Name	Type	Length	Description
tn_sol	float	4	Inversion Solution (watts-per-range-Doppler-bin)—Thermal noise power estimate calculated as one of many variables in the chi-square solution for the surface scattering function nr_sig0. Likely to be an overestimate since there is no attempt to account for radar clutter; nr_thnsol includes contributions from Venus' surface, the radar equipment, and aliased echo signal in both time/range and frequency.

[6] The one-bit flags are defined by the decimal number that contains that bit, To test the value of, for example, the ''range peak'' flag you should form the logical AND of nr_flags and 16. If the result is non-zero, the flag is ''set''.

tn_solv	float	4	Estimated Variance of nr_thnsol (watts^2-per-range-Doppler-bin)—Estimate of variance in nr_thnsol from propagation of errors through solution procedure.
tn_min	float	4	Smallest Range-Doppler Array Value (watts-per-range-Doppler-bin)—Smallest value in averaged 16 by 151 (frequency by range, respectively) array of processor output power. Likely to be an underestimate, since statistical variations will force the "minimum" below the average.
tn_avg	float	4	Average of Small Range-Doppler Values (watts-per-range-Doppler-bin)—the average of range echo bin values from 10–20 range bins before the echo peak (divided by 16).
tn_r	float	4	Minimum from Range Echo (watts-per-range-Doppler-bin)—the minimum value in the range echo, divided by 16.

5.4.2.3. Altimetry Inversion Calibration Details

Table 5-5c. Stanford Altimetry Inversion Calibration Details (calib_t)

Off	Len	Type	Name	Description
+0	1	uchar	cl_TXA	Transmitter A flag
1	1	uchar	cl_RXA	Receiver A flag
2	2	uchar	cl_pad1[2]	spares
4	4	float	cl_Cpt0	End-to-end system correction (dB)
8	4	float	cl_xstrap	Cross-strapping correction (dB)
12	4	float	cl_dCTX	Transmitter power correction (dB)
16	4	float	cl_TT1	Transmitter Stage 1 temperature (K)
20	4	float	cl_TOA	ONU Altimeter temperature (K)
24	4	float	cl_atmos	Atmospheric attenuation (dB)
28	4	float	cl_ant	Antenna pattern correction (dB)
32	4	float	cl_TRX	Receiver temperature (K)
36	4	float	cl_dCT	Receiver temperature attenuation (dB)
40	1	uchar	cl_rac	Commandable attenuation code
41	3	uchar	cl_pad2[3]	spares
44	4	float	cl_dCA	Receiver commandable attenuation (dB)
48	4	float	cl_CALT	Total amplitude correction (dB)
52				

Element Name	Type	Length	Description
cl_TXA	uchar	1	Transmitter A flag-if set (1), transmitter A was used; if not set (0), transmitter B was used.
cl_RXA	uchar	1	Receiver A flag-if set (1), receiver A was used; if not set (0), receiver B was used.
cl_pad1[2]	uchar	2	spares
cl_Cpt0	float	4	End-to-end system correction (dB)-the end-to-end gain of the complete altimetry radar system for a closed loop test [if the antenna were removed and the outgoing (transmitted) signal were turned directly back to the receiver-including processing at Stanford]. The value of cl_Cpt0 is the measured attenuation during this test.
cl_xstrap	float	4	Cross-strapping correction (dB)-the attenuation caused by using transmitter A with receiver B, or vice versa.
cl_dCTX	float	4	Transmitter power correction (dB)-an estimated attenuation of the available power, relative to cl_Cpt0, based on telemetered measurements of transmitter and output network temperatures.
cl_TT1	float	4	Transmitter Stage 1 temperature (K)-the telemetered temperature of the Transmitter Stage 1 Driver temperature, used to compute the transmit power.
cl_TOA	float	4	ONU Altimeter temperature (K)-the telemetered temperature of the ONU Altimeter temperature, used to compute the transmit power.
cl_atmos	float	4	Atmospheric attenuation (dB)-the expected attenuation due to the atmosphere for this nadir elevation (nr_pvrad).
cl_ant	float	4	Antenna pattern correction (dB)-always zero because the gain pattern of the antenna is accounted for in the G-matrix calculation.
cl_TRX	float	4	Receiver temperature (K)-telemetered temperature of the receiver.
cl_dCT	float	4	Receiver temperature attenuation (dB)-the portion of receiver attenuation that is dependent on receiver temperature.
cl_rac	uchar	1	Commandable attenuation code-the 3-bit code specifying the amount of attenuation used in the receiver front end. (See Table 5-5d and [12] for the SAB header format.)
cl_pad2[3]	uchar	3	spares
cl_dCA	float	4	Receiver commandable attenuation (dB)-the actual receiver attenuation specified by the attenuation code cl_rac.
cl_CALT	float	4	Total amplitude correction (dB)-the total amplitude correction expressed as an attenuation and computed from the formula:

cl_CALT = cl_Cpt0 + cl_xstrap + cl_dCTX +
cl_atmos + cl_ant + cl_dCT + cl_dCA

The raw data are then calibrated by multiplication (in power) by $10^{CALT/10}$.

5.4.2.4. Altimetry Inversion SAB Header

The SAB Header is carried forward from the ALT-EDR tape. Its format is summarized in Table 5-5d; more detailed information is available in [12].

Table 5-5d. Stanford Altimetry Inversion SAB Header (sab_hdr_t)

Length (bits)	Description
32	JPL sync code 0x03915ED3
192	BAQ threshold data (24 8-bit words)
20	Spares (filled with zeroes)
12	Emissivity data
12	Spares (filled with zeroes)
52	Spacecraft time
16	Spares (filled with zeroes)
80	Status field
16	Buffer memory, checkout flag

5.5. Inversion Fit File

The Inversion Fit File has the general structure shown in Figure 5-6.

Figure 5-6. Stanford Inversion Fit File (NFF) - Block Format

T		CCSD1Z000001	CCSDS Label	CCSDS Header
L		00000xxx	Length Field	
V	T	NJPL1K00KL00	K-Label	
	L	00000xxx	Length Field	
	V	PRODUCT_FILE_NAME=NFFnnnnn.v PRODUCT_TYPE=INV_FIT_FILE MISSION_ID=4 MISSION_NAME=MAGELLAN SPACECRAFT_ID=18 SPACECRAFT_NAME=MAGELLAN ORBIT_NUMBER=nnnnn UPLOAD_IC=cccccc NAV_UNIQUE_ID=cccccc HARDWARE_VERSION_ID=nnn MAJOR_SOFTWARE_VERSION_ID=nnn MINOR_SOFTWARE_VERSION_ID=nnn PROCESS_TIME=YYYY-MM-DDThh:mm:ss.fff DATA_FORMAT_TYPE=cccc	Keywords and Values	Keyword and Value SFDU
	T	NJPL1I000007	I-Label	Inversion Fit Hdr SFDU (Table 5-6)
	L	00000xxx	Length Field	
	V	Data Fields for Inversion Fit Header		
	T	CCSD1R000003	Start Label	Aggr Start Marker
	L	000000xx	Length Field	
	V	DELIMITER=SMARKER PRODUCT_NAME=INVERSION_FIT TYPE=NJPL1I000026	Start Value	
	T	NJPL1I000008	I-Label	Inversion Fit Data Records (Table 5-7)
	L	00000xxx	Length Field	
	V	Data Fields for Inversion Fit Data	Data Records	
	T	CCSD1R000003	End Label	Aggr end Marker
	L	000000xx	Length Field	
	V	DELIMITER=EMARKER PRODUCT_NAME=INVERSION_FIT	End Value	

CCSDS Label `CCSD1Z000001´, the CCSDS primary SFDU label.

Length Field Eight bytes, ASCII, with leading zeroes mandatory; the length of the remainder of the Inversion Fit File header.

Keyword and Value SFDU See Section 5.1.3.

Inversion Fit Header Record	See Table 5-6.
Aggregation Start Marker	
Start Label	`CCSD1R000003´, the SFDU Aggregation Marker label, indicating the start of a data aggregation of unspecified length. This aggregation consists of a varying number of Inversion Fit Record SFDU's (nf_rec), as shown in Table 5-7.
Length Field	Eight bytes, ASCII, with leading zeroes mandatory; the length of the remainder of the aggregation marker SFDU.
Start Value	
DELIMITER=	The character string `SMARKER´, indicating that this is the start of a data aggregation.
PRODUCT_NAME=	The character string `INVERSION_FIT'
TYPE=	The character string `NJPL1I000026´, where `0026´ indicates that the data between the SMARKER and EMARKER labels comprise a registered SFDU aggregation (the Inversion Fit Aggregate), composed of a set of registered NJPL aggregates.
Inversion Fit Data Record	See Table 5-7.
Aggregation End Marker	
End Label	`CCSD1R000003´, the SFDU Aggregation Marker label, indicating the end of a data aggregation of unspecified length. This matches the above "Start Marker".
Length Field	Eight bytes, ASCII, with leading zeroes mandatory; the length of the remainder of the aggregation marker SFDU.
End Value	
DELIMITER=	The character string `EMARKER´, indicating that this is the end of a data aggregation.
PRODUCT_NAME=	The character string `INVERSION_FIT´.

Table 5-6. Stanford Inversion Fit Header Record (fh_rec)

Off	Len	Type	Name	Description
+0	20	sfdu	fh_sfdu	SFDU label and length
20	4	long	fh_orb	Orbit number
24	4	long	fh_ver	Orbit version
28	2	short	fh_sslfit_major	Program SSLFIT major version number
30	2	short	fh_sslfit_minor	Program SSLFIT minor version number
32	2	short	fh_altinv_major	Program ALTINV major version number
34	2	short	fh_altinv_minor	Program ALTINV minor version number
36	2	short	fh_alt_major	Program ALT major version number
38	2	short	fh_alt_minor	Program ALT minor version number
40	4	long	fh_nrec	Number of inversion fit records
44	2	short	fh_nlaw	Number of synthetic scattering laws
46	1	uchar	fh_meth_inv	Inversion method ID
47	1	uchar	fh_meth_sig	Variance estimation method ID
48	1	uchar	fh_meth_Gamsig	Constraint variance method ID
49	1	uchar	fh_meth_thermal	Thermal noise method ID
50	1	uchar	fh_meth_frot	Doppler rotation method ID
51	1	uchar	fh_meth_echo	Range echo processing ID
52	1	uchar	fh_meth_bmax	Maximum angle method ID
53	1	uchar	fh_specf	Non-delta spectral filter flag
54	2	uchar	fh_pad[2]	spares
56	16	uchar	fh_spare[16]	spares
72				

Element Name	Type	Length	Description
fh_sfdu	sfdu	20	SFDU Label and Length: `NJPL1I0000070000nnnn´. The number `0007´ is registered with the NJPL SFDU authority as the "Stanford Inversion Fit Header Record".
fh_orb	long	4	Orbit Number-orbit number for the data to be fit.

fh_ver	long	4	Orbit Version Number-version number for the altimetry data file used in this processing. Obtained from the VERSION_ID keyword of the corresponding ALT-EDR Orbit Header File (NB: This turns out not to be a good indicator of the version of the data file; the Orbit Header File itself is rarely updated).
fh_sslfit_major	short	2	Program SSLFIT Major Version Number-the number of the major software version of Stanford program SSLFIT used to fit these data.
fh_sslfit_minor	short	2	Program SSLFIT Minor Version Number-the number of the minor software version of Stanford program SSLFIT used to fit these data.
fh_altinv_major	short	2	Program ALTINV Major Version Number-the number of the major software version of Stanford program ALTINV that produced the scattering function solutions.
fh_altinv_minor	short	2	Program ALTINV Minor Version Number-the number of the minor software version of Stanford program ALTINV that produced the scattering function solutions.
fh_alt_major	short	2	Program ALT Major Version Number-the number of the major software version of Stanford program ALT used to carry out the range-Doppler processing on these data.
fh_alt_minor	short	2	Program ALT Minor Version Number-the number of the minor software version of Stanford program ALT used to carry out the range-Doppler processing on these data.
fh_nrec	long	4	Number of Inversion Fit Records in File-the number of inversions (solutions for the surface scattering law) and, hence, the number of fitted result records in this file; equal to nh_nrec.
fh_nlaw	short	2	Number of Synthetic Scattering Laws-the number of synthetic scattering laws compared against the scattering solution; "synthetic" scattering laws can include Hagfors, exponential, Gaussian, Rayleigh, and Muhleman (see Table 5-9).
fh_meth_inv	uchar	1	Inversion Method ID-Identifier for inversion method (carried forward from corresponding Altimetry Inversion Header Record; see Table 5-3).
fh_meth_sig	uchar	1	Variance Estimation Method ID-Identifier for variance estimation technique (carried forward from corresponding Altimetry Inversion Header Record; see Table 5-3).
fh_meth_Gamsig	uchar	1	Constraint Variance Method ID-Identifier for variance constraint technique (carried forward from corresponding Altimetry Inversion Header Record; see Table 5-3).
fh_meth_thermal	uchar	1	Thermal Noise Method ID-Identifier for thermal noise estimation technique (carried forward from corresponding Altimetry Inversion Header Record; see Table 5-3).

fh_meth_frot	uchar	1	Doppler Rotation Method ID-Identifier for Doppler rotation technique (carried forward from corresponding Altimetry Inversion Header Record; see Table 5-3).
fh_meth_echo	uchar	1	Range Echo Processing ID-Identifier for range echo processing technique (carried forward from corresponding Altimetry Inversion Header Record; see Table 5-3).
fh_meth_bmax	uchar	1	Maximum Angle Method ID-Identifier for technique to set maximum incidence angle in solution (carried forward from corresponding Altimetry Inversion Header Record; see Table 5-3).
fh_specf	uchar	1	Non-Delta Spectral Filter Flag-set if Doppler spectrum was filtered before the inversion (carried forward from corresponding Altimetry Inversion Header Record; see Table 5-3).
fh_pad[2]	uchar	2	spares
fh_spare[16]	uchar	16	spares

Table 5-7. Stanford Inversion Fit Data Record SFDU (fr_rec)

Off	Len	Type	Name	Description
+0	20	sfdu	fr_sfdu	SFDU label and length
20	4	ulong	fr_nfoot	Footprint number
24	4	ulong	fr_nlaw	Number of synthetic scattering laws
28	4	uchar	fr_spare[4]	Spares
Repeating sets of fit results (below) for fr_nlaw scattering laws				
--	4	uchar	fr_slaw	Scattering law ID
--	4	ulong	fr_flags	Flag fields (see Table 5-8)
--	4	float	fr_p1	Fit parameter #1 (see Table 5-9)
--	4	float	fr_p1v	Fit parameter #1 variance
--	4	float	fr_p2	Fit parameter #2 (see Table 5-9)
--	4	float	fr_p2v	Fit parameter #2 variance
--	4	float	fr_rmss	RMS slope for p1, p2 (see Table 5-9)
--	4	float	fr_rmsv	RMS slope variance
--	4	float	fr_resid	Residual error in fit
N	N=32+36*fr_nlaw			

Element Name	Type	Length	Description
fr_sfdu	sfdu	20	SFDU Label and Length: `NJPL1I0000080000nnnn´. The number `0008´ is registered with the NJPL SFDU authority as the "Inversion Fit Data Record".
fr_nfoot	ulong	4	The Inversion Fit Record Footprint Number-starting from 1, the number of the Inversion Fit Data Record; equal to the Footprint Number nr_nfoot in the corresponding Altimetry Inversion Data Record.
fr_nlaw	ulong	4	Number of Synthetic Scattering Laws-the number of synthetic scattering laws compared against the scattering solution; "synthetic" scattering laws can include Hagfors, exponential, Gaussian, Rayleigh, and Muhleman. Same as fh_nlaw except for type and length.
fr_spare[4]	uchar	4	spares
			The following block of entries will be repeated fr_nlaw times
fr_slaw	char	4	Scattering Law ID-a 4-letter identifier for one of several analytic scattering functions which can be fitted to fr_sig0. Possible values, and the subsequent interpretation for fr_p1 and fr_p2, are shown in Table 5-9.
fr_flags	ulong	4	Flag Fields (see Table 5-8).
fr_p1	float	4	Scattering law parameter #1 (see Table 5-9).
fr_p1v	float	4	Variance in fr_p1.
fr_p2	float	4	Scattering law parameter #2 (see Table 5-9).
fr_p2v	float	4	Variance in fr_p2.
fr_rmss	float	4	RMS Tilt for Fitted Function (radians)(see Table 5-9)
fr_rmsv	float	4	Variance of fr_rmss (radians2)
fr_resid	float	4	Residual Error in Fit-Residual between analytic function (Table 5-9) and scattering function from inversion of data for best choices of fr_p1 and fr_p2.

End of repeated block

Table 5-8. Stanford Inversion Fit Record Flag Values (fr_flags)		
Name	Value	Flag Description (see footnote 7)
FR_FLAGS_P1MAX	1	p1 fit failed: p1 too large
FR_FLAGS_P1MIN	2	p1 fit failed: p1 too small

The rms tilt for the Muhleman function is approximated by a power law fit to data obtained by numerical integration. This fit is accurate to within 1% of the numerical integration results over the range $0.0008<\alpha<0.7$. It is not accurate outside this region.

$rms = c_1 + c_2 \alpha^{c_3}$, $c_1 = -0.0046$, $c_2 = 1.5450$, $c_3 = 0.4696$

Table 5-9 Stanford Scattering Function Definitions

Scattering Law ID	Analytic Expression $\sigma_0(\theta)$	Param #1 (rad)	Param #2	RMS Tilt (rad)
'EXP'	$\dfrac{0.5A\sec\theta\exp\left\lvert\dfrac{-\tan\theta}{\tan\theta_0}\right\rvert}{(1.06-\sqrt{1.73\tan^2\theta_0+0.0031})\tan^2\theta_0}$	θ_0	A	$2.4\theta_0$
'GAU'	$A\dfrac{\sec^4\theta}{\tan^2\theta_0}\exp\left\lvert\dfrac{-\tan^2\theta}{\tan^2\theta_0}\right\rvert$	θ_0	A	θ_0
'HAG'	$\dfrac{\rho C}{2}(\cos^4\theta+C\sin^2\theta)^{-\frac{3}{2}}$	C	ρ	$C^{-1/2}$
'MUH'	$\beta\cos\theta(\sin\theta+\alpha\cos\theta)^{-3}$	α	β	see above
'RAY'	$1.1284A\dfrac{\tan\theta\sec^4\theta}{\tan^3\theta_0}\exp\left\lvert\dfrac{-\tan^2\theta}{\tan^2\theta_0}\right\rvert$	θ_0	A	$1.2\theta_0$

[7] The one-bit flags are defined by the decimal number that contains that bit. To test the value of, for example, the ''p1 too small'' flag you should form the logical AND of fr_flags and 2. If the result is non-zero, the flag is ''set''.

5.6. Image Data Files

Each set of SCVDR files contains two Image Data Files, one for C-BIDR data in sinusoidal equal area projection (SIN Image Data File, or SIF) and one for C-BIDR data in oblique sinusoidal equal area projection (OBL Image Data File, or OIF). Both have the same format, which is shown in Figure 5-7.

Figure 5-7. Stanford Image Data File (SIF and OIF) - Block Format

T		CCSD1Z000001	CCSD Label	CCSDS Header
L		00000xxx	Length Field	
V	T	NJPL1K00KL00	K-Label	
	L	00000xxx	Length Field	
	V	PRODUCT_FILE_NAME=SIFnnnnn.v PRODUCT_TYPE=ccc_IMAGE_FILE MISSION_ID=4 MISSION_NAME=MAGELLAN SPACECRAFT_ID=18 SPACECRAFT_NAME=MAGELLAN ORBIT_NUMBER=nnnnn UPLOAD_ID=cccccc NAV_UNIQUE_ID=cccccc HARDWARE_VERSION_ID=nnn MAJOR_SOFTWARE_VERSION_ID=nnn MINOR_SOFTWARE_VERSION_ID=nnn PROCESS_TIME=YYYY-MM-DDThh:mm:ss.fff DATA_FORMAT_TYPE=cccc	Keywords and Values	Keyword and Value SFDU
	T	NJPL1I000010	I-Label	Image Header SFDU (Table 5-10)
	L	00000xxx	Length Field	
	V	Data Fields for Image Header Record		
	T	CCSD1R000003	Start Label	Aggr Start Marker
	L	000000xx	Length Field	
	V	DELIMITER=SMARKER PRODUCT_NAME=ccc_IMAGE_DATA TYPE=NJPL1I000027	Start Value	
	T	NJPL1I000012	I-Label	Image Data SFDUs (Table 5-11)
	L	00000xxx	Length Field	
	V	Data Fields for Image Data Record	Data Records	
	T	CCSD1R000003	End Label	Aggr End Marker
	L	000000xx	Length Field	
	V	DELIMITER=EMARKER PRODUCT_NAME=ccc_IMAGE_DATA	End Value	

CCSDS Label `CCSD1Z000001´, the CCSDS primary SFDU label.

Length Field Eight bytes, ASCII, with leading zeroes mandatory; the length of the remainder of the Image Data File header.

Keyword and Value SFDU	See Section 5.1.3.
Image Header Record	See Table 5-10.
Aggregation Start Marker	
Start Label	`CCSD1R000003´, the SFDU Aggregation Marker label, indicating the start of a data aggregation of unspecified length. This aggregation consists of a varying number of Image Data Record SFDU's (ir_rec), as shown in Table 5-11.
Length Field	Eight bytes, ASCII, with leading zeroes mandatory; the length of the remainder of the aggregation marker SFDU.
Start Value	
DELIMITER=	The character string `SMARKER´, indicating that this is the start of a data aggregation.
PRODUCT_NAME=	The character string `ccc_IMAGE_DATA´ where `ccc´ stands for `SIN´ (Sinusoidal Image Data Files) or `OBL´ (Oblique Image Data Files).
TYPE=	The character string `NJPL1I000027´, where `0027´ indicates that the data between the SMARKER and EMARKER labels comprise a registered SFDU aggregation (the Image Aggregate), composed of a set of registered NJPL aggregates.
Image Data Record	See Table 5-11.
Aggregation End Marker	
End Label	`CCSD1R000003´, the SFDU Aggregation Marker label, indicating the end of a data aggregation of unspecified length. This matches the above "Start Marker".
Length Field	Eight bytes, ASCII, with leading zeroes mandatory; the length of the remainder of the aggregation marker SFDU.
End Value	
DELIMITER=	The character string `EMARKER´, indicating that this is the end of a data aggregation.
PRODUCT_NAME=	The character string `ccc_IMAGE_DATA´ where `ccc´ stands for `SIN´ (Sinusoidal Image Data Files) or `OBL´ (Oblique Image Data Files).

Table 5-10. Stanford Image Header Record SFDU (ih_rec)

Off	Len	Type	Name	Description
+0	20	sfdu	ih_sfdu	SFDU label and length
20	4	long	ih_orb	Orbit number
24	4	long	ih_ver	Orbit version number
28	4	long	ih_nrec	Number of Image Data Records in file
32	4	long	ih_sqlside	Number of image lines per data record
36	1	uchar	ih_bidrf	Source data type
37	1	uchar	ih_lsqr	Fitting method flag
38	2	short	ih_rmap major	Program RMAP major software version
40	2	short	ih_rmap minor	Program RMAP minor software version
42	2	short	ih_maxB	Maximum number of incidence angles
44	2	short	ih_maxI	Maximum number of intensity bins
46	2	uchar	ih_pad[2]	spares
48	12	uchar	ih_spare[12]	spares
60				

Element Name	Type	Length	Description
ih_sfdu	sfdu	20	SFDU Label and Length: `NJPL1I00001000000nnnn´. The number `0010´ is registered with the NJPL SFDU authority as the "Image Header Record".
ih_orb	long	4	Orbit Number-the Magellan orbit number for the data represented in these data records.
ih_ver	long	4	Orbit Version Number-the version of the image data file used for these results. Obtained from the VERSION_ID keyword of the corresponding C-BIDR (or F-BIDR) Orbit Header File (NB: This turns out not to be a good indicator of the version of the data file; the Orbit Header File itself is rarely updated).
ih_nrec	long	4	Number of Image Data Records in this File-the number of image records that follow this header.
ih_sqlside	long	4	Number of Image Lines per Data Record-the number of C-BIDR (or F-BIDR) image lines compressed to form one output processed record (nominally 9).
ih_bidrf	uchar	1	Source Data Type Flag-set to binary 0 if source data are from an F-BIDR, set to 1 if from a C-BIDR.

ih_lsqr	uchar	1	Fitting Method Flag-0 for chi-square fitting to determine polynomial coefficients, 1 for linear least squares fitting.
ih_rmap_major	short	2	Program RMAP Major Software Version Number-the major software version number of the Stanford program RMAP used to obtain the scattering function from the image data.
ih_rmap_minor	short	2	Program RMAP Minor Software Version Number-the minor software version number of the Stanford program RMAP used to obtain the scattering function from the image data.
ih_maxB	short	2	Maximum number of incidence angles-the largest value of ir_nth that will appear in this orbit.
ih_maxI	short	2	Maximum number of intensity bins-the largest value of ir_nI that will appear in this orbit.
ih_pad[2]	uchar	2	spares
ih_spare[12]	uchar	12	spares

Original image data are grouped into "blocks" of nominally 9 C-BIDR image lines during Stanford RMAP processing [9]. Nine lines of C-BIDR data correspond to an approximately rectangular surface area with narrow dimension 2.025 km and long dimension equal to the swath width. The nature of SAR processing precludes identification of a unique burst responsible for any pixel, line, or block; but each burst has a Mid-Range Point, selected during SAR processing [8]. The burst associated with the Mid-Range Point closest to the center of the block (ir_burst) is called the "associated burst" and is used to specify the observing geometry for the block.

Table 5-11. Stanford Image Data Record SFDU (ir_rec)

Off	Len	Type	Name	Description
+0	20	sfdu	ir_sfdu	SFDU label and length
20	4	long	ir_nfoot	Footprint number
24	4	ulong	ir_burst	Burst count for closest associated burst
28	4	ulong	ir_flags	Flag fields (see Table 5-12)
32	8	double	ir_scet	Footprint time (SCET, TDB)
40	3*4	float	ir_scpos[3]	Spacecraft position vector (km, VBF85)
52	3*4	float	ir_scvel[3]	Spacecraft velocity vector (km, VBF85)
64	3*4	float	ir_bpv[3]	SAR antenna unit boresight vector (VBF85)
76	3*4	float	ir_bip[3]	Boresight intercept point (km VBF85)
88	4	float	ir_lat	Footprint latitude (degrees, VBF85)

Table 5-11 (contd). Stanford Image Data Record SFDU (ir_rec)

92	4	float	ir_lon	Footprint longitude (degrees E, VBF85)
96	4	float	ir_azimuth	Azimuth from footprint to spacecraft (deg)
100	2	char	ir_poln	Polarization
102	2	uchar	ir_pad1[2]	spares
104	4	float	ir_xfoot	Along-track footprint size (km)
108	4	float	ir_yfoot	Across-track footprint size (km)
112	4	float	ir_mrp lat	Mid-range point latitude (deg N)
116	4	float	ir_mrp lon	Mid-range point longitude (deg E)
120	4	float	ir_mrp inc	Mid-range point incidence angle (deg)
124	4	long	ir_mrp C1	Mid-range point C1 coordinate
128	4	long	ir_mrp C2	Mid-range point C2 coordinate
132	4	float	ir_bip lat	BIP latitude (deg N)
136	4	float	ir_bip lon	BIP longitude (deg E)
140	4	float	ir_bip inc	BIP incidence angle (deg)
144	4	float	ir_bip elev	BIP elevation
148	4	float	ir_bip range	Apparent range from spacecraft to BIP (km)
152	4	float	ir_mrp bs coef	Normalizing factor for pixel values
156	4	float	ir_theta offset	Lowest incidence angle (deg)
160	4	float	it_theta max	Highest incidence angle (deg)
164	4	float	ir_thlo	Lowest incidence angle for fit (deg)
168	4	float	it_thhi	Highest incidence angle for fit (deg)
172	1	uchar	ir_bmin	Lowest valid bin for incidence angle fit
173	1	uchar	ir_bmax	Highest valid bin for incidence angle fit
174	1	uchar	ir_nth	Number of angles in ir_bins
175	1	uchar	ir_polysize	Size of polynomial fit
176	4	float	ir_chisq	Chi-square value from linear fit

Table 5-11 (contd). Stanford Image Data Record SFDU (ir_rec)

180	3*4	float	ir_coefs[3]	Coefficients for polynomial fit
192	1	uchar	ir_Imin	Lowest valid bin for intensity data
193	1	uchar	ir_Imax	Highest valid bin for intensity data
194	1	uchar	ir_nI	Number of intensity levels in ir_I count
195	5	uchar	ir_pad2[5]	spares
200	8	uchar	ir_spare[8]	spares
208	p	bin t	ir_bins[n]	Backscatter data for n=ir_nth angles; p=12*n
208+p	4*m	ulong	ir_I count[m]	Histogram of pixel values for m=ir_nI levels
N	N=208+p+4*m			

Element Name	Type	Length	Description
ir_sfdu	sfdu	20	SFDU Label and Length: `NJPL1I0000120000nnnn´. The designator `0012´ is registered with the NJPL SFDU authority as the "Image Data Record".
ir_nfoot	long	4	The Image Data Record Footprint Number-starting from 1, the number of the Image Data Record by increasing Image Footprint Time (ir_scet).
ir_burst	ulong	4	Burst Count for Closest Associated Burst—the burst for which the Mid-Range Point is closest to the footprint center (see above).
ir_flags	ulong	4	Flag fields—see Table 5-13.
ir_scet	double	8	Image Footprint Time (SCET)—the burst start time (seconds of TDB since J2000; see Section 1.5.4.2) for the associated burst.
ir_scpos[3]	float	3*4	Spacecraft Position Vector (km, VBF85)—the spacecraft position for the associated burst, relative to the Venus center of mass and expressed in the Venus Body Fixed 1985 coordinate system.
ir_scvel[3]	float	3*4	Spacecraft Velocity Vector (km sec^{-1}, VBF85)—the spacecraft velocity for the associated burst, relative to the Venus center of mass and expressed in Venus Body Fixed 1985 coordinates.
ir_bpv[3]	float	3*4	High-Gain (SAR) Antenna Boresight Vector (VBF85)—unit vector along the axis of the SAR antenna for the associated burst, expressed in Venus Body Fixed 1985 coordinates.

ir_bip[3]	float	3*4	Boresight Intercept Point Vector (km, VBF85)—the position of the boresight intercept point on Venus' surface for the associated burst, expressed in Venus Body Fixed 1985 coordinates.
ir_lat	float	4	Footprint Latitude (degrees N, VBF85)—the body-fixed latitude of the footprint center, in the range of –90 (South Pole) to +90 (North Pole).
ir_lon	float	4	Footprint Longitude (degrees E, VBF85)—the body-fixed longitude of the footprint center, in the range of 0–360.
ir_azimuth	float	4	Azimuth from Footprint to Spacecraft (degrees)—at the footprint center (ir_lat, ir_lon) the spacecraft azimuth measured positive toward the east from local north.
ir_poln	char	2	Measurement Polarization—horizontal transmitted and horizontal received (`HH´) or vertical transmitted and vertical received (`VV´).
ir_pad1[2]	uchar	2	spares
ir_xfoot	float	4	Along-Track Altimetry Footprint Size (km)—the along-track dimension of the Venus surface area described by this data record (nominally 9 C-BIDR image lines, or 2.025 km).
ir_yfoot	float	4	Across-Track Altimetry Footprint Size (km)—the across-track dimension of the Venus surface area described by this data record.
ir_mrp_lat	float	4	Mid-Range Point Latitude (degrees N)—the latitude of the Mid-Range Point for the associated burst.
ir_mrp_lon	float	4	Mid-Range Point Longitude (degrees E)—the longitude of the Mid-Range Point for the associated burst.
ir_mrp_inc	float	4	Mid-Range Point Incidence Angle (degrees)—the incidence angle at the Mid-Range Point for the associated burst.
ir_mrp_C1	long	4	Mid-Range Point C1 Coordinate—the C1 coordinate at the Mid-Range Point for the associated burst in units of 225 m pixels (see [8] for definition of C1/C2 coordinates).
ir_mrp_C2	long	4	Mid-Range Point C2 Coordinate—the C2 coordinate at the Mid-Range Point for the associated burst in units of 225 m pixels (see [8] for definition of C1/C2 coordinates).
ir_bip_lat	float	4	BIP Latitude (degrees N)—the latitude at the Boresight Intercept Point for the associated burst (the Boresight Intercept Point is the point on the Venus surface where the HGA boresight would intercept the surface, after accounting for atmospheric refraction and the Magellan-adopted model for topography).
ir_bip_lon	float	4	BIP Longitude (degrees E)—the longitude at the Boresight Intercept Point for the associated burst.

ir_bip_inc	float	4	BIP Incidence Angle (degrees)—the incidence angle at the Boresight Intercept Point for the associated burst.
ir_bip_elev	float	4	BIP Elevation (km)—the elevation (above the 6051 km reference surface) at the Boresight Intercept Point for the associated burst.
ir_bip_range	float	4	BIP Range (km)—the apparent slant range from the spacecraft to the Boresight Intercept Point for the associated burst.
ir_mrp_bs_coef	float	4	Mid-Range Point Backscatter Coefficient—the Muhleman Law backscatter coefficient at the Mid-Range Point reported on the CBIDR tape. NB: this value was not computed correctly [8].
ir_theta_offset	float	4	Lowest Incidence Angle (degrees)—the smallest angle represented by the scattering data array.
ir_theta_max	float	4	Highest Incidence Angle (degrees)—the largest angle represented by the scattering data array.
ir_thlo	float	4	Lowest Incidence Angle for Fit (degrees)—the smallest incidence angle for which at least one pixel was found in the block; the smallest incidence angle used in the polynomial fit.
ir_thhi	float	4	Highest Incidence Angle for Fit (degrees)—the largest incidence angle for which at least one pixel was found in the block; the largest incidence angle used in the polynomial fit.
ir_bmin	uchar	1	Lowest Valid Bin for Incidence Angle Fit—the smallest bin number for which data were used in the polynomial fit ($0 \leq$ ir_bmin ≤ 99).
ir_bmax	uchar	1	Highest Valid Bin for Incidence Angle Fit—the largest bin number for which data were used in the polynomial fit ($0 \leq$ ir_bmax ≤ 99).
ir_nth	uchar	1	Number of Angles in ir_bins—the dimension of the array ir_bins (equal to ir_bmax–ir_bmin+1).
ir_polysize	uchar	1	Size of the Polynomial Fit—the number of coefficients in the fitted polynomial; one more than the highest power in the polynomial.
ir_chisq	float	4	Chi-Square Value from Linear Fit—the residual from the weighted least-square error fit for the polynomial.
ir_coefs[3]	float	3*4	Coefficients for Polynomial Fit—the coefficients for the fitted polynomial to the scattering function, which is expanded about (ir_thlo+ir_thhi)/2. The first coefficient (ir_coefs[0]) is the constant term, the second coefficient (ir_coefs[1]) is the linear term, ...
ir_Imin	uchar	1	Lowest Valid Bin for Intensity Data—the smallest pixel intensity represented by the pixel intensity histogram ($0 \leq$ ir_Imin ≤ 255)
ir_Imax	uchar	1	Highest Valid Bin for Intensity Data—the highest pixel intensity represented by the pixel intensity histogram ($0 \leq$ ir_Imax ≤ 255).

ir_nI	uchar	1	Number of Intensity Levels in Histogram—the dimension of array ir_I_count (ir_nI = ir_Imax–ir_Imin+1).
ir_pad2[5]	uchar	5	spares
ir_spare[8]	uchar	8	spares
ir_bins[n]	bin_t	12*n	Backscatter Data for up to 100 Angles—at n=ir_nth angles the pixel intensity, number of pixels, and standard deviation of the weighted intensity (Table 5-12). The angles are equally spaced from ir_thlo to ir_thhi, inclusive.
ir_I_count[m]	ulong	4*m	Histogram of Pixel Values for up to 256 Intensity Levels—the number of pixels at each of m=ir_nI intensity levels.

Table 5-12. Stanford Image Statistics Data Structure (bin_t)

Off	Len	Type	Name	Description
+0	4	float	inten	Cumulative intensity
4	4	ulong	count	Number of pixels
8	4	float	sdev	Standard deviation

Element Name	Type	Length	Description
inten	float	4	Cumulative Intensity-the sum of the intensities of all pixels assigned to this incidence angle bin
count	ulong	4	Number of Pixels-the number of pixels assigned to this incidence angle bin
sdev	float	4	Standard Deviation-the standard deviation of the weighted intensities for this incidence angle bin.

Table 5-13 Stanford Image Data Record Flag Values (ir_flags)

Name	Value	Flag Description
IR_FLAGS_TRUNC	1	Set for orbits 2601-4515 (indicates that pixel values below 90 may have been truncated

5.7. Emissivity Data File

The Emissivity Data File has the general structure shown in Figure 5-8.

Figure 5-8. Stanford Emissivity Data File (EDF) - Block Format

T		CCSD1Z000001	CCSDS Label	CCSDS Header
L		00000xxx	Length Field	
V	T	NJPL1K00KL00	K-Label	
	L	00000xxx	Length Field	
	V	PRODUCT_FILE_NAME=EDFnnnnn.v PRODUCT_TYPE=EMISSIVITY_FILE MISSION_ID=4 MISSION_NAME=MAGELLAN SPACECRAFT_ID=18 SPACECRAFT_NAME=MAGELLAN ORBIT_NUMBER=nnnnn UPLOAD_ID=cccccc NAV_UNIQUE_ID=cccccc HARDWARE_VERSION_ID=nnn MAJOR_SOFTWARE_VERSION_ID=nnn MINOR_SOFTWARE_VERSION_ID=nnn PROCESS_TIME=YYYY-MM-DDThh:mm:ss.fff DATA_FORMAT_TYPE=cccc	Keywords and Values	Keyword and Value SFDU
	T	NJPL1I000021	I-Label	Ems Data Header SFDU (Table 5-14)
	L	00000xxx	Length Field	
	V	Data Fields for Emissivity Header		
	T	CCSD1R000003	Start Label	Aggr Start Marker
	L	000000xx	Length Field	
	V	DELIMITER=SMARKER PRODUCT_NAME=EMISSIVITY_DATA TYPE=NJPL1I000028	Start Value	
	T	NJPL1I000022	I-Label	Ems Data Record SFDUs (Table 5-15)
	L	00000xxx	Length Field	
	V	Data Fields for Emissivity Data Recs	Data Records	
	T	CCSD1R000003	End Label	Aggr End Marker
	L	000000xx	Length Field	
	V	DELIMITER=EMARKER PRODUCT_NAME=EMISSIVITY_DATA	End Value	

CCSDS Type `CCSD1Z000001´, the CCSDS primary SFDU label..

Length Field Eight bytes, ASCII, with leading zeroes mandatory; the length of the remainder of the Emissivity Data File header.

Keyword and Value SFDU See Section 5.1.3.

Emissivity Header Record See Table 5-14.

Aggregation Start Marker

Start Label `CCSD1R000003´, the SFDU Aggregation Marker label, indicating the start of a data aggregation of unspecified length. This aggregation consists of a varying number of Emissivity Data Record SFDU's (er_rec), as shown in Table 5-15.

Length File Eight bytes, ASCII, with leading zeroes mandatory; the length of the remainder of the aggregation marker SFDU.

Start Value

`DELIMITER=` The character string `SMARKER´, indicating that this is the start of a data aggregation.

`PRODUCT_NAME=` The character string `EMISSIVITY_DATA´.

`TYPE=` The character string `NJPL1I000028´, where `0028´ indicates that the data between the SMARKER and EMARKER labels comprise a registered SFDU aggregation (the Emissivity Aggregate), composed of a set of registered NJPL aggregates.

Emissivity Data Record See Table 5-15.

Aggregation End Marker

End Label `CCSD1R000003´, the SFDU Aggregation Marker label, indicating the end of a data aggregation of unspecified length. This matches the above "Start Marker".

Length Field Eight bytes, ASCII, with leading zeroes mandatory; the length of the remainder of the aggregation marker SFDU.

End Value

`DELIMITER=` The character string `EMARKER´, indicating that this is the end of a data aggregation.

`PRODUCT_NAME=` The character string `EMISSIVITY_DATA´.

Table 5-14. Stanford Emissivity Header Record SFDU (eh_rec)

Off	Len	Type	Name	Description
+0	20	sfdu	eh_sfdu	SFDU emissivity header label and length
20	4	long	eh_orb	Orbit number
24	4	long	eh_ver	Orbit version number
28	2	short	eh_radi_major	Program RADI major version number
30	2	short	eh_radi_minor	Program RADI minor version number
32	4	long	eh_nrec	Number of Emissivity Data Records in file

Table 5-14 (contd). Stanford Emissivity Header Record SFDU (eh_rec)

36	2	short	eh_radp_major	Program RADP major version number
38	2	short	eh_radp_minor	Program RADP minor version number
40	2	short	eh_engex_major	Program ENGEX major version number
42	2	short	eh_engex_minor	Program ENGEX minor version number
44	2	short	eh_sabex_major	Program SABEX major version number
46	2	short	eh_sabex_minor	Program SABEX minor version number
48	2	short	eh_rcomp_major	Program RCOMP major version number
50	2	short	eh_rcomp_minor	Program RCOMP minor version number
52	2	short	eh_ratm_major	Program RATM major version number
54	1	uchar	eh_meth_quat	Method ID for quaternion correction
55	1	uchar	eh_meth_Tsky	Method ID for sky temperature estimation
56	1	uchar	eh_meth_Tvenus	Method ID for Venus temperature estimation
57	1	uchar	eh_meth_beam_eff	Method ID for HGA beam efficiency estimation
58	1	uchar	eh_meth_rho	Method ID for Fresnel reflectivity estimation
59	1	uchar	eh_meth_var	Method ID for emissivity and Tb variance estimation
60	1	uchar	eh_meth_syst	Method ID for systematic error correction
61	1	uchar	eh_meth_geom	Method ID for spacecraft geometry calculations
62	1	uchar	eh_meth_telem	Method ID for telemetry calculations
63	1	uchar	eh_pad	spare
64	4	float	eh_Tvenus	Venus disk apparent brightness temp (K)
68	4	float	eh_Tcosmic	Cosmic background effective temperature (K)
72	4	float	eh_beam_eff	HGA beam efficiency
76	4	float	eh_rad_eff	HGA radiation efficiency
80	12	uchar	eh_spare[12]	spares
+92				

Element Name	Type	Length	Description
eh_sfdu	sfdu	20	SFDU Label and Length: `NJPL1I0000210000nnnn´. The number `0021´ is registered with the NJPL SFDU authority as the "Emissivity Header Record".
eh_orb	long	4	Orbit Number—the Magellan orbit number for the data represented in these data records.
eh_ver	long	4	Orbit Version Number—orbit version number for these data. Obtained from the VERSION_ID keyword of the corresponding C-BIDR Orbit Header File (NB: This turns out not to be a good indicator of the version of the data file; the Orbit Header File itself is rarely updated).
eh_radi_major	short	2	Program RADI Major Version Number—the number of the major software version of Stanford program RADI used to process these data.
eh_radi_minor	short	2	Program RADI Minor Version Number—the number of the minor software version of Stanford program RADI used to process these data.
eh_nrec	long	4	Number of Emissivity Records in File—the number of emissivity records in this file.
eh_radp_major	short	2	Program RADP major version number—the number of the major software version of Stanford program RADP used to process these data.
eh_radp_minor	short	2	Program RADP minor version number—the number of the minor software version of Stanford program RADP used to process these data.
eh_engex_major	short	2	Program ENGEX major version number—the number of the major software version of Stanford program ENGEX used to process these data.
eh_engex_minor	short	2	Program ENGEX minor version number—the number of the minor software version of Stanford program ENGEX used to process these data.
eh_sabex_major	short	2	Program SABEX major version number—the number of the major software version of Stanford program SABEX used to process these data.
eh_sabex_minor	short	2	Program SABEX minor version number—the number of the minor software version of Stanford program SABEX used to process these data.
eh_rcomp_major	short	2	Program RCOMP major version number—the number of the major software version of Stanford program RCOMP used to process these data.

eh_rcomp_minor	short	2	Program RCOMP minor version number—the number of the minor software version of Stanford program RCOMP used to process these data.
eh_ratm_major	short	2	Program RATM major version number—the number of the major software version of Stanford program RATM used to process these data.
eh_meth_quat	uchar	1	Method ID for quaternion correction—code number for the specific method for determining the quaternion correction (if any). Possible values are: 0 Use uplinked values with no correction (preferred) 1 Use delta-quaternions from telemetry stream, as reported in image Processing Parameter files
eh_meth_Tsky	uchar	1	Method ID for sky temperature estimation—code number for the specific method for determining sky temperature as seen at the surface of Venus. Possible values are: 0 Constant value = eh_Tcosmic (preferred) 1 (not used)
eh_meth_Tvenus	uchar	1	Method ID for Venus temperature estimation—code number for the specific method of determining the effective global temperature of Venus as seen at the spacecraft. Possible values are: 0 Constant value = eh_Tvenus (preferred) 1 (unused)
eh_meth_beam_eff	uchar	1	Method ID for HGA beam efficiency estimation—code number for the specific method of determining high-gain antenna beam efficiency. Possible values are: 0 Constant value = eh_beam_eff (preferred) 1 (not used)
eh_meth_rho	uchar	1	Method ID for estimating Fresnel reflectivity—code number for the specific method for estimating the surface Fresnel reflectivity appropriate for the sky brightness reflection at the surface. Possible values are: 0 Assume reflectivity is the complement of emissivity (preferred) 1 (not used)
eh_meth_var	uchar	1	Method ID for emissivity variance estimation—code number for the specific method of determining the variance expected in the estimates of Venus surface brightness and emissivity. Possible values are: 0 Assume the standard deviation is proportional to the estimate itself, where the proportionality factor is determined from the results of method 1 for typical data (preferred) 1 Monte Carlo simulation
eh_meth_syst	uchar	1	Method ID for systematic error correction—code number for the specific method for correcting the radiometry signal for systematic effects (such as capacitive discharge associated with altimeter bursts). Possible values are: 0 Make no systematic corrections (preferred) 1 (not used)

eh_meth_geom	uchar	1	Method ID for spacecraft geometry calculations—code number for the specific method for computing the spacecraft position, velocity and orientation Possible values are: 0 Use values reported in C-BIDR image processing parameters files 1 Use original ephemeris, clock and pointing files on C-BIDR tapes (preferred)
eh_meth_telem	uchar	1	Method ID for telemetry calculations—code number for the specific method for computing and conditioning the spacecraft telemetry signals. Possible values are: 0 Use values reported in C-BIDR image processing parameters files 1 Use original engineering telemetry files on C-BIDR tapes and condition data with a combination of median filters and smoothing filters (preferred)
eh_pad	uchar	1	spare
eh_Tvenus	float	4	Venus surface temperature (K)—the effective (global) brightness temperature of Venus as seen at the spacecraft (nominally 635K).
eh_Tcosmic	float	4	Cosmic background effective temperature (K)—the cosmic background temperature (nominally 3K) for emissivity measurements at Venus.
eh_beam_eff	float	4	HGA beam efficiency—the high-gain antenna beam efficiency used for interpreting emissivity measurements (nominally 0.8).
eh_rad_eff	float	4	HGA radiation efficiency—the high-gain antenna radiation efficiency used for interpreting emissivity measurements (nominally 0.977).
eh_spare[12]	uchar	12	spares

Table 5-15. Stanford Emissivity Data Record SFDU (er_rec)

Off	Len	Type	Name	Description
+0	20	sfdu	er_sfdu	SFDU label and length
20	4	long	er_nfoot	Footprint number
24	4	long	er_burst	SAB Number
28	4	ulong	er_flags	Flag fields (see Table 5-16)
32	8	double	er_scet	S/C Emissivity Epoch (SCET, TDB)
40	3*4	float	er_scpos[3]	S/C Position Vector (km, J2000)
52	3*4	float	er_alta[3]	ALT Boresight Pointing Vector (J2000)
64	3*4	float	er_sara[3]	HGA Boresight Pointing Vector (J2000)
76	4	float	er_lat	Footprint Latitude (deg, VBF85)

Table 5-15 (contd). Stanford Emissivity Data Record SFDU (er_rec)

80	4	float	er_lon	Footprint Longitude (deg, VBF85)
84	4	float	er_azimuth	Azimuth from footprint to spacecraft (deg)
88	2	char	er_poln	Polarization
90	2	uchar	er_pad1[2]	spares (not used)
92	4	float	er_radius	Footprint Planetary Radius (km)
96	4	float	er_inc	Footprint Incidence Angle (deg)
100	10	uchar	er_ss prev[10]	SAR Status field for previous burst
110	10	uchar	er_ss ant[10]	SAR Status field for antenna burst
120	10	uchar	er_ss cal[10]	SAR Status field for calibration burst
130	1	uchar	er_xmtA	Transmitter A flag
131	1	uchar	er_rcvA	Receiver A flag
132	1	uchar	er_onuA	ONU A flag
133	3	uchar	er_pad2[3]	spares (not used)
136	4	float	er_S	Calibrated Radiometer Signal (counts)
140	4	float	er_Sprime	Corrected Radiometer Signal (counts)
144	4	float	er_CAL	Calibration Load Signal (counts)
148	4	float	er_Trcv	Receiver Physical Temperature (K)
152	4	float	er_Tsi	Sensor Input Noise Temperature (K)
156	5*4	float	er_Tsen[5]	Cable Sensor Temperatures (K)
176	4	float	er_Tant	HGA Antenna Noise Temperature (K)
180	4	float	er_Thga	HGA Reflector Physical Temperature (K)
184	4	float	er_TSfeed	S-band Feed Physical Temperature (K)
188	4	float	er_Tsky	Effective Sky Brightness Temperature (K)

Table 5-15 (contd). Stanford Emissivity Data Record SFDU (er_rec)

192	4	float	er_OmegaV	Venus Disk Subtended Angle (steradians)
196	4	float	er_alpha	Atmospheric Power Transmission Coefficient
200	4	float	er_Tsurf	Physical Surface Temperature (K)
204	4	float	er_Tup	Upwelling Atmospheric Brightness Temp (K)
208	4	float	er_Tdn	Downwelling Atmospheric Brightness Temp
212	4	float	er_Tb	Derived Venus Surface Brightness Temperature
216	4	float	er_Tbv	Variance of er_Tb
220	4	float	er_emiss	Derived Surface Emissivity
224	4	float	er_emissv	Variance in er_emiss
228	4	uchar	er_pad3[4]	spares
232	8	uchar	er_spare[8]	spares
240				

Element Name	Type	Length	Description
er_sfdu	sfdu	20	SFDU label `NJPL1I00002200000nnn´. The number `0022´ is registered with the NJPL SFDU authority as the "Emissivity Data Record".
er_nfoot	long	4	Footprint Number—starting from 1, the number of the Emissivity Data Record by increasing emissivity footprint time (er_scet), starting at 1.
er_burst	long	4	SAB Number—the number assigned to the burst header that contains the antenna measurement (as opposed to the calibration measurement) referenced by this er_rec.
er_flags	ulong	4	Flag fields—see Table 5-16.
er_scet	double	8	S/C Emissivity Epoch (SCET)—the ephemeris time (seconds of TDB since J2000; see Section 1.5.4.2) at which the emissivity measurement was made.
er_scpos[3]	float	3*4	S/C Position Vector (km, J2000)—the S/C position at er_scet, relative to the Venus center of mass, expressed in inertial coordinates.
er_alta[3]	float	3*4	ALT Pointing Vector (J2000)—the altimetry antenna pointing vector at er_scet, expressed as a unit vector in inertial coordinates.

er_sara[3]	float	3*4	HGA Pointing Vector (J2000)—the HGA pointing vector at er_scet, expressed as a unit vector in inertial coordinates.
er_lat	float	4	Footprint Latitude (degrees N, VBF85)—the body-fixed latitude, at er_scet, of the boresight intercept point (obtained from the C-BIDR Processing Parameters file).
er_lon	float	4	Footprint Longitude (degrees E, VBF85)—the body-fixed longitude, at er_scet, of the boresight intercept point (obtained from the C-BIDR Processing Parameters file).
er_azimuth	float	4	Azimuth from Footprint to Spacecraft (degrees)—at (er_lat, er_lon) the spacecraft azimuth measured positive toward the east from local north.
er_poln	char	2	Measurement Polarization—horizontal received (`HH´) or vertical received (`VV´).
er_pad1[2]	uchar	2	spares (not used)
er_radius	float	4	Footprint Planetary Radius (km)—the estimated planetary radius at the boresight intercept point (obtained from the C-BIDR Processing Parameters file).
er_inc	float	4	Footprint Incidence Angle (deg)—the incidence angle at the boresight intercept point (obtained from the C-BIDR Processing Parameters file).
er_ss_prev[10]	uchar	10	SAR Status Field for Previous Burst—the original SAB header status field from the burst preceding the Antenna Measurement, of interest because the Antenna Measurement actually occurs during this burst (see [12], page 23).
er_ss_ant[10]	uchar	10	SAR Status Field for Antenna Measurement—the original SAB header status field used for the radiometry (emissivity) measurement (see [12], page 23).
er_ss_cal[10]	uchar	10	SAR Status Field for Calibration Measurement—the original SAB header status field used for the radiometry (emissivity) calibration (see [12], page 23).
er_xmtA	uchar	1	Transmitter A Flag—if set (1), transmitter A was active; if not set (0) transmitter B was active.
er_rcvA	uchar	1	Receiver A Flag—if set (1), receiver A was active; if not set (0), receiver B was active.
er_onuA	uchar	1	ONU A flag—if set (1), ONU A was active; if not set (0), ONU B was active.
er_pad2[3]	uchar	3	spares (not used)

er_S	float	4	Calibrated Radiometer Signal (counts)—the difference between the antenna radiometry (emissivity) measurement ANT and the calibration measurement er_CAL (er_S = ANT–er_CAL), in units of radiometer counts. This value has been corrected for non-systematic radiometric effects, but has not been corrected for systematic errors.
er_Sprime	float	4	Corrected Radiometer Signal (counts)—the radiometer signal after correction for systematic errors (see eh_meth_syst), in units of radiometer counts.
er_CAL	float	4	Radiometer Calibration Signal (counts)—the radiometer measurement when it is connected to the reference load, in units of radiometer counts. This value has been corrected for non-systematic radiometric effects.
er_Trcv	float	4	Receiver Physical Temperature (K)—the physical temperature of the SAR receiver as reported from telemetry in image Processing Parameter files.
er_Tsi	float	4	Sensor Input Noise Temperature (K)—the system temperature of the sensor RF input port, obtained from the radiometry (emissivity) signal and compensated for receiver gain and temperature.
er_Tsen[5]	float	5*4	Cable Sensor Temperatures (K)—the physical temperatures reported by five sensors along the cable between the antenna and the receiver front end.
er_Tant	float	4	HGA Antenna Noise Temperature (K)—the system temperature of the HGA antenna, determined from the sensor input noise temperature and the loss and physical temperature of the HGA cable.
er_Thga	float	4	HGA Reflector Physical Temperature (K)—obtained from engineering telemetry channel E–0100.
er_TSfeed	float	4	S-Band Feed Physical Temperature (K)—obtained from engineering telemetry channel E–0098.
er_Tsky	float	4	Effective Sky Brightness Temperature (K)—the sky brightness in the forward scatter (specular) direction, nominally equal to eh_Tcosmic but computed according to eh_meth_Tsky.
er_OmegaV	float	4	Venus Disk Subtended Angle (steradians)—the solid angle subtended by the Venus disk at the spacecraft.
er_alpha	float	4	Atmospheric Power Transmission Coefficient—the one-way power transmission factor for the atmosphere between the point at (er_lat, er_lon, er_radius) and the spacecraft using the atmospheric model in [2].
er_Tsurf	float	4	Physical Surface Temperature (K)—the physical temperature of the surface obtained from the assumed radius at the boresight intercept point (er_radius) and the (Magellan-adopted) model for atmospheric structure [2].

er_Tup	float	4	Upwelling Atmospheric Brightness Temperature (K)—effective temperature of the atmosphere resulting from self-emission along the raypath determined by the HGA.
er_Tdn	float	4	Downwelling Atmospheric Brightness Temperature (K)—effective temperature of the atmosphere observed at the surface along an incoming ray that, after specular reflection from the (average) spherical surface, would reach the spacecraft.
er_Tb	float	4	Derived Venus Surface Brightness Temperature (K)—brightness temperature of the Venus surface derived from the radiometry (emissivity) measurements.
er_Tbv	float	4	Variance of er_Tb (K^2)—Variance of the derived Venus brightness temperature using the method identified by eh_meth_var.
er_emiss	float	4	Derived Surface Emissivity—the emissivity of the Venus surface.
er_emissv	float	4	Variance in er_emiss—variance of the derived emissivity using the method identified by eh_meth_var.
er_pad3[4]	uchar	4	spares
er_spare[8]	uchar	8	spares

Table 5-16. Stanford Emissivity Data Record Flag Values (er_flags)

Name	Value	Flag Description
ER_FLAGS_HGA	1	HGA boresight misses planet
ER_FLAGS_CLOCK	2	Error occurred in SCLK to SCET conversion, probably indicating bit error in telemetry.
ER_FLAGS_QUAT	4	Quaternions and HGA pointing from image parameter file differ by more than (nominally) 0.1 degree.
ER_FLAGS_SPACING	8	Telemetry data separation from radiometry measurement exceeds (nominally) 5 seconds.

5.8. G-Matrix File

The general structure of the G-Matrix File is shown in Figure 5-9.

Figure 5-9. Stanford G-Matrix File (GMF) - Block Format

T		CCSD1Z000001	CCSDS Label	CCSDS Header
L		00000xxx	Length Field	
V	T	NJPL1K00KL00	K-Label	
	L	00000xxx	Length Field	
	V	PRODUCT_FILE_NAME=GMFnnnnn.v PRODUCT_TYPE=G_MATRIX_FILE MISSION_ID=4 MISSION_NAME=MAGELLAN SPACECRAFT_ID=18 SPACECRAFT_NAME=MAGELLAN ORBIT_NUMBER=nnnnn UPLOAD_ID=cccccc NAV_UNIQUE_ID=cccccc HARDWARE_VERSION_ID=nnn MAJOR_SOFTWARE_VERSION_ID=nnn MINOR_SOFTWARE_VERSION_ID=nnn PROCESS_TIME=YYYY-MM-DDThh:mm:ss.fff DATA_FORMAT_TYPE=cccc	Keywords and Values	Keyword and Value SFDU
	T	NJPL1I000023	I-Label	G-Matrix Header SFDU (Table 5-17)
	L	00000xxx	Length Field	
	V	Fields for G-Matrix Header Record		
	T	CCSD1R000003	Start Label	Aggr Start Marker
	L	000000xx	Length Field	
	V	DELIMITER=SMARKER PRODUCT_NAME=G_MATRIX_DATA TYPE=NJPL1I000029	Start Value	
	T	NJPL1I000024	I-Label	G-Matrix Data SFDUs (Table 5-18)
	L	00000xxx	Length Field	
	V	Data Fields for G-Matrix Data Record	Data	
	T	CCSD1R000003	End Label	Aggr End Marker
	L	000000xx	Length Field	
	V	DELIMITER=EMARKER PRODUCT_NAME=G_MATRIX_DATA	End Value	

CCSDS Type `CCSD1Z000001´, the CCSDS primary SFDU label.

Length Field Eight bytes, ASCII, with leading zeroes mandatory; the length of the remainder of the G-Matrix File header.

Keyword and Value SFDU See Section 5.1.3.

G-Matrix Header Record See Table 5-17.

Aggregation Start Marker

Start Label `CCSD1R000003´, the SFDU Aggregation Marker label, indicating the start of a data aggregation of unspecified length. This aggregation consists of a varying number of G-Matrix Data Record SFDU's (gr_rec), as shown in Table 5-18.

Length Field Eight bytes, ASCII, with leading zeroes mandatory; the length of the remainder of the aggregation marker SFDU.

Start Value

DELIMITER= The character string `SMARKER´, indicating that this is the start of a data aggregation.

PRODUCT_NAME= The character string `G_MATRIX_DATA´.

TYPE= The character string `NJPL1I000029´, where `0029´ indicates that the data between the SMARKER and EMARKER labels comprise a registered SFDU aggregation (the G-Matrix Aggregate), composed of a set of registered NJPL aggregates.

G-Matrix Data Records See Table 5-18.

Aggregation End Marker

End Label `CCSD1R000003´, the SFDU Aggregation Marker label, indicating the end of a data aggregation of unspecified length. This matches the above "Start Marker".

Length Field Eight bytes, ASCII, with leading zeroes mandatory; the length of the remainder of the aggregation marker SFDU.

End Value

DELIMITER= The character string `EMARKER´, indicating that this is the end of a data aggregation.

PRODUCT_NAME= The character string `G_MATRIX_DATA´.

Table 5-17. Stanford G-Matrix Header Record SFDU (gh_rec)

Off	Len	Type	Name	Description
+0	20	sfdu	gh_sfdu	SFDU inversion header label and length
20	2	short	gh_ng	Number of G-matrices
22	2	short	gh_maxB	Maximum size of angle vector
24	2	short	gh_maxR	Maximum size of range vector
26	2	short	gh_maxF	Maximum size of frequency vector
28	4	long	gh_maxBR	Maximum size of angle-range matrix
32	4	long	gh_maxBF	Maximum size of angle-frequency matrix
36	8	uchar	gh_spare[8]	spares
44				

Element Name	Type	Length	Description
gh_sfdu	sfdu	20	SFDU Label and Length: `NJPL1I0000230000nnnn'. The number `0023´ is registered with the NJPL SFDU authority as the "G-Matrix Header Record".
gh_ng	short	2	Number of G-Matrices—the number of G-matrices contained in this file.
gh_maxB	short	2	Maximum size of angle vector—the largest value of gr_blen in this file.
gh_maxR	short	2	Maximum size of range vector—the largest value of gr_rlen in this file.
gh_maxF	short	2	Maximum size of frequency vector—the largest value of gr_flen in this file.
gh_maxBR	long	4	Maximum size of angle-range matrix—the largest value of the product gr_blen * gr_rlen in this file.
gh_maxBF	long	4	Maximum size of angle-frequency matrix—the largest value of the product gr_blen * gr_flen in this file.
gh_spare[8]	uchar	8	spares

Table 5-18. Stanford G-Matrix Data Record SFDU (gr_rec)

Off	Len	Type	Name	Description
+0	20	sfdu	gr_sfdu	SFDU label and length
20	2	short	gr_Gnum	G-matrix ID number
22	2	short	gr_orb	Orbit number
24	4	long	gr_burst	Burst number within orbit
28	4	uchar	gr_pad1[4]	spares
32	8	double	gr_scet	Burst time (SCET, TDB)
40	4	float	gr_lat	Nadir latitude (degrees N, VBF85)
44	4	float	gr_lon	Nadir longitude (degrees E, VBF85)
48	3*8	double	gr_scpos[3]	Spacecraft position (km, J2000)
72	3*8	double	gr_scvel[3]	Spacecraft velocity (km/sec, J2000)
96	3*8	double	gr_alta[3]	Unit boresight ALT pointing vector (J2000)
120	3*8	double	gr_sara[3]	Unit boresight SAR pointing vector (J2000)
144	2	short	gr_blen	Number of angles

Table 5-18 (contd). Stanford G-Matrix Data Record SFDU (gr_rec)

146	2	short	gr_rlen	Number of ranges
148	2	short	gr_flen	Number of frequencies
150	2	short	gr_ralias	Highest order range aliasing included
152	2	short	gr_falias	Highest order frequency aliasing included
154	2	uchar	gr_pad2[2]	spares
156	16	uchar	gr_spare[16]	spares
172	4*nb	float	gr_b[nb]	Angle vector, nb=gr_blen; p=4*nb
172+p	4*nr	float	gr_r[nr]	Range vector, nr=gr_rlen; q=4*nr+p
172+q	4*nf	float	gr_f[nf]	Frequency vector, nf=gr_flen; r=4*nf+q
172+r	4*nb*nr	float	gr_gbr	Angle-range G-matrix; s=4*nb*nr+r
172+s	4*nb*nf	float	gr_gbf	Angle-Doppler G-matrix; t=4*nb*nf+s
N	N=172+t=172+4*gr_blen*(1+gr_rlen+gr_flen)+4*gr_rlen+4*gr_flen			

Element Name	Type	Length	Description
gr_sfdu	sfdu	20	SFDU Label and Length: `NJPL1I0000240000nnnn´. The number `0024´ is registered with the NJPL SFDU authority as the "G-Matrix Data Record".
gr_Gnum	short	2	G-Matrix ID—the identifier for the G-matrix (see nr_Gnum in Section 5.4.2). G-matrices are indexed from 0.
gr_orb	short	2	Orbit Number—the orbit number for which the G-matrix was computed.
r_burst	long	4	Burst Number—the burst number within orbit gr_orb for which the G-matrix was computed.
r_pad1[4]	uchar	4	spares (not used)
r_scet	double	8	Burst Time (SCET, TDB)—the time at which burst gr_burst was transmitted (SCET, TDB).
gr_lat	float	4	Nadir Latitude (degrees N, VBF85)—the latitude at the nadir point for the G-matrix calculation.

gr_lon	float	4	Nadir Longitude (degrees E, VBF85)—the longitude at the nadir for the G-matrix calculation.
gr_scpos[3]	double	3*8	Spacecraft Position Vector (km, J2000)—the spacecraft position at gr_scet, relative to the Venus center of mass, expressed in inertial coordinates.
gr_scvel[3]	double	3*8	Spacecraft Velocity Vector (km sec^{-1}, J2000)—the spacecraft velocity at gr_scet, relative to the Venus center of mass, expressed in inertial coordinates.
gr_alta[3]	double	3*8	Altimetry Antenna Boresight Vector (J2000)—unit vector along the axis of the altimetry antenna at gr_scet, expressed in inertial coordinates.
gr_sara[3]	double	3*8	SAR Antenna Boresight Vector (J2000)—unit vector along the axis of the high-gain (SAR) antenna at gr_scet, expressed in inertial coordinates.
gr_blen	short	2	Number of Angles—the number of angles in the calculated G-matrix.
gr_rlen	short	2	Number of Ranges—the number of ranges in the calculated G-matrix.
gr_flen	short	2	Number of Frequencies—the number of frequencies in the calculated G-matrix (an odd number).
gr_ralias	short	2	Range Aliasing—the highest order of range aliasing included in the computation of the G-matrix. If 0, no aliasing was considered; if 1, the contribution due to the first range ambiguity, etc.
gr_falias	short	2	Frequency Aliasing—the highest order of frequency aliasing included in the computation of the G-matrix. If 0, no aliasing was considered; if 1, the contributions due to the first positive and negative frequency aliasing, etc.
gr_pad2[2]	uchar	2	spares
gr_spare[16]	uchar	16	spares
gr_b[nb]	float	4*nb	Angle Vector—the vector of nb=gr_blen angles for which the G-matrix was calculated (radians). Entries in gr_b are monotonically increasing from an initial 0 radians, which is implicit and not included in the vector. Entries gr_b[n] and gr_b[n+1] thus bound the nth angle interval, which has nominal value (gr_b[n]+gr_b[n+1])/2.
gr_r[nr]	float	4*nr	Range Vector—the vector of nr=gr_rlen ranges for which the G-matrix was calculated (seconds). Entries in gr_r are monotonically increasing from an initial 0 seconds, which is implicit and not included in the vector. Entries gr_r[n] and gr_r[n+1] thus bound the nth range interval, which has nominal value (gr_r[n]+gr_r[n+1])/2.

gr_f[nf]	float	4*nf	Frequency Vector—the vector of nf=gr_flen frequencies for which the G-matrix was calculated (Hz). Entries in gr_f are monotonically increasing and denote frequencies at the centers of nominal frequency bins. gr_f has an odd number of elements; the center element is zero and the remainder are symmetric (positive and negative frequencies) about this center value.
gr_gbr[nrb]	float	4nr*nb	Angle-Range G-Matrix—the (aliased) G-matrix in angle-range space, with gr_rlen rows and gr_blen columns, stored in row-major order for a total of nrb=gr_rlen*gr_blen entries. The first row is associated with the first element in gr_r, and each element in a row is associated with the corresponding element in gr_b.
gr_gbf[nfb]	float	4nf*nb	Angle-frequency G-Matrix—the (aliased) G-matrix in angle-frequency space, with gr_flen rows and gr_blen columns, stored in row-major order for a total of nfb=gr_flen*gr_blen entries. The first row is associated with the first element in gr_f, and each element in a row is associated with the corresponding element in gr_b.

5.9. Volume Trailer File

Figure 5-10. Stanford Volume Trailer File (VTF) Format

T		CCSD1Z000001	CCSDS Label	CCSDS Header
L		00000060	Length Field	
V	T	CCSD1R000003	End Label	Aggr End Marker
	L	00000040	Length Field	
	V	DELIMITER=EMARKER	End Value	
		PRODUCT_NAME=SCVDR		

CCSDS Label `CCSD1Z000001´, the CCSDS primary SFDU label..

Length Field Eight bytes, ASCII, with leading zeroes mandatory; the length of the remainder of the trailer file.

Aggregation End Marker

End Label `CCSD1R000003´, the SFDU Aggregation Marker label, indicating the end of a data aggregation of unspecified length. This matches the Aggregation Marker in the Volume Header File.

Length Field Eight bytes, ASCII, with leading zeroes mandatory; the length of the remainder of the aggregation marker SFDU.

End Value

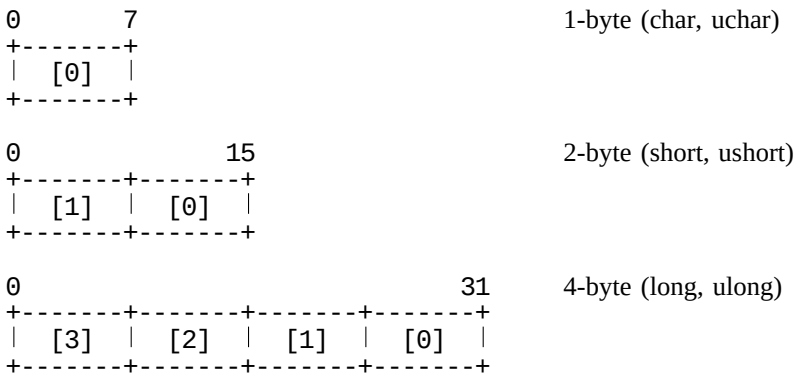
`DELIMITER=` The character string `EMARKER´, indicating that this is the end of a data aggregation.

`PRODUCT_NAME=` The character string `SCVDR´.

APPENDIX A

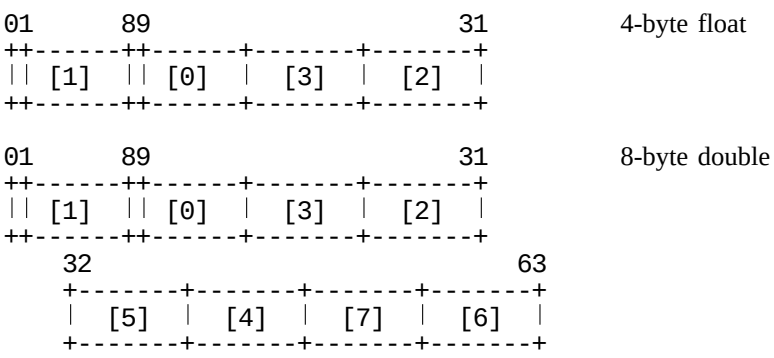
BINARY DATA FORMAT

A. VAX Integer Fields



VAX binary integers are stored in one, two, or four consecutive 8-bit bytes. Unsigned integers uchar, ushort, ulong, which always represent positive values, contain 8, 16, or 32 binary bits, respectively. As illustrated above, the significance increases from the rightmost bit to the leftmost (bit 0). Signed integers (char, short, long) are stored in the same way, except that negative values are formed by taking the corresponding positive value, complementing each bit, then adding unity-known as "two's complement" format. As a consequence, a negative value always has bit 0 set "on". Integers are written externally in increasing byte-number order, i.e. `[0]`, `[1]`, etc., so that less significant bits always precede more significant ones. For example, the short value –2 is stored as a pair of bytes valued `0xfe`, `0xff`.

B. VAX Floating-Point Fields



VAX single- (double-) precision floating point numbers[1] are stored in four (eight) consecutive bytes. Bit number 0 contains a sign indicator, S. Bits 1 through 8 contain a binary exponent, E. The significance increases from bit 8 through bit 1. Bits 9 through 31 (63) contain a mantissa M, a 23-bit (55-bit) binary fraction whose binary point lies immediately to the left of bit 9. The significance increases from bit 31 (63) through bit 9. The value of

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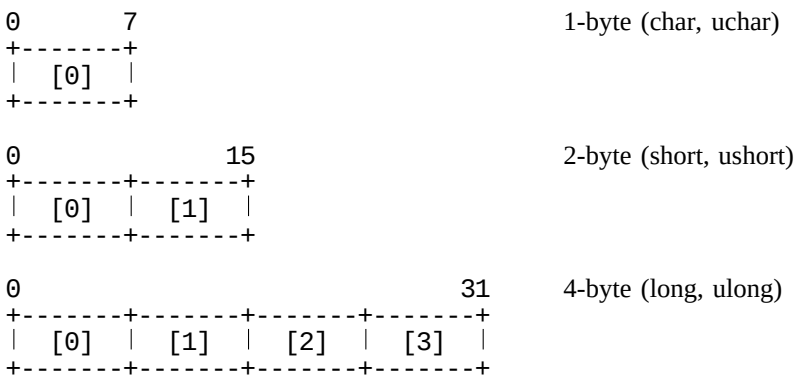
[1] Known to VAX enthusiasts as F-type and D-type floating-point formats, respectively.

the field is given by

$$(-1)^S 2^{E-129}(1+M)$$

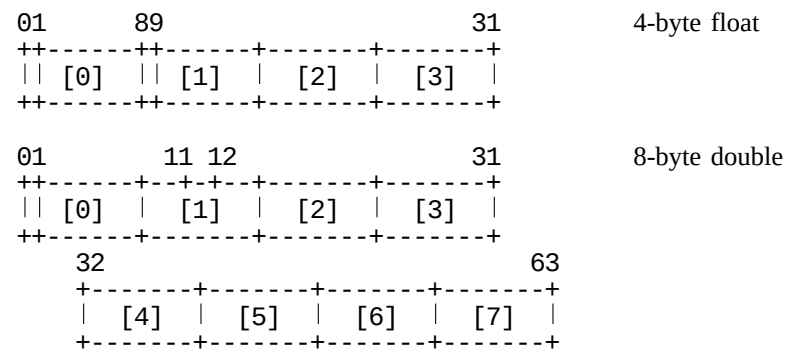
The numbers are stored externally in increasing byte-number order, i.e. `[0]`, `[1]`, etc. For example, the float value +1.0 is stored as four bytes valued `0x80`, `0x40`, `0x00`, `0x00`.

C. IEEE Integer Fields



IEEE binary integers are stored in one, two, or four consecutive 8-bit bytes. Unsigned integers uchar, ushort, ulong, which always represent positive values, contain 8, 16, or 32 binary bits, respectively. As illustrated above, the significance increases from the rightmost bit to the leftmost (bit 0). Signed integers (char, short, long) are stored in the same way, except that negative values are formed by taking the corresponding positive value, complementing each bit, then adding unity-known as "two's complement" format. As a consequence, a negative value always has bit 0 set "on". Integers are written externally in increasing byte-number order, i.e. `[0]`, `[1]`, etc., so that more significant bits always precede less significant ones. For example, the short value –2 is stored as a pair of bytes valued `0xff`, `0xfe`.

D. IEEE Floating-Point Fields



IEEE single- (double-) precision floating point numbers are stored in four (eight) consecutive bytes. Bit number 0 contains a sign indicator, S. Bits 1 through 8 (11) contain a binary exponent, E. The significance increases from bit 8 (11) through bit 1. Bits 9 (12) through 31 (63) contain a mantissa M, a 23-bit (52-bit) binary fraction whose binary point lies immediately to the left of bit 9. The significance increases from bit 31 (63) through bit 9 (11). The value of the field is given by

$$(-1)^S 2^{E-127}(1+M)$$

for single-precision, and

$$(-1)^S 2^{E-1023}(1+M)$$

for double-precision.

The numbers are stored externally in increasing byte-number order, i.e. `[0]`, `[1]`, etc. For example, the maximum float value +3.40282347E+38 is stored as four bytes valued `0x7f`, `0x7f`, `0xff`, `0xff`.

Special float values are represented as +Infinity (`0x7f800000`), -Infinity (`0xff800000`), quiet NaN (not a number) (`0xffffffff`), and signaling NaN (`0x7f800001`).