Cassini Composite Infrared Spectrometer (CIRS)

Planetary Data System (PDS)
Time Sequential Data Record (TSDR)
and Spectral Image Cube
Archive Volume Software Interface Specification (SIS)

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1 Preface

This document describes the format and contents of the Cassini Composite Infrared Spectrometer (CIRS) Time Sequential Data Record (TSDR) and Spectral Image Cube Archive Volume Collection.

1.1 Acronyms and Abbreviations

ASU	Arizona State University
ASCII	American Standard Code for Information Interchange
CD	Compact Disk
CIRS	Composite Infrared Spectrometer
DVD	Digital Video Disk or Digital Versatile Disk
FOV	File Of View
HTML	Hyper-Text Markup Language
IFM	Interferogram
MGS	Mars Global Surveyor
NAIF	Navigation and Ancillary Information Facility
NMSU	New Mexico State University
NSSDC	The National Space Sciences Data Center
ODL	Object Description Language (PDS)
PERL	Practical Extraction and Report Language
PDS	Planetary Data System
PDF	Portable Document Format
SDVT	Science Data Verification Team
SIS	Software Interface Specification
SSAI	Science Systems and Applications, Inc.
TES	Thermal Emission Spectrometer
TSDR	Time Sequential Data Record
UMD	University of Maryland
ZPD	Zero Path Difference (of IFM)

Table 1: Acronyms and Abbreviations

1.2 Glossary

Data element: a piece of data, such as a character string or integer number.

Field: a column in the data table, or species of data element.

Fragment: an individual computer file, which forms part of the logical table. A fragment is a sub-table, which when combined with all other fragments in the search path, combine to form the logical search table. Fragments come in different types. Each type stores certain fields. The fields in different fragment types do not overlap, except for 1 to 3 key fields. The key fields are scet time, detector number, and target id.

Glossary: an explanation and definition of terms used in the context of this document.

Logical table: the logical table is the effective data table which the Vanilla search program sees. Although the table is stored as many individual file fragments, it is searchable as one giant table.

Target ID: the NAIF number corresponding to a target body.

Volume: one self-contained subset of the entire data collection, such as several months worth of data together with documentation. Usually, one volume will be sized to fit on a single unit of portable media, such as a CD-ROM.

1.3 MGS TES Heritage

The authors acknowledge the substantial legacy of the Mars Global Surveyor (MGS) Thermal Emission Spectrometer (TES) instrument team's work in developing core elements of the data system now being used by the CIRS team. This includes software (Vanilla), acronyms such as the 'TSDR', many of the data file types (OBS etc), and also the documentation (SISs), which the current document follows closely. Any inaccuracies or omissions are entirely the fault of the current authors.

1.4 Revision Notes

June 1st 2012 - Overall revision to include the Spectral Image Cube information. Edited :

- Document title
- Preface
- Introduction/Content Overview
- Archive Volume Content adding new sub-sections :
  - Adding sub-section Cube
  - Adding sub-section Extra
- Sub-section Index

2014-12-05, M. Kaelberer, Vertical profile directory name corrected.
2018-02-13, M. Kaelberer, Staff list updated and oispm table added.

2 Introduction

2.1 Content Overview

The Composite Infrared Spectrometer (CIRS) is an instrument onboard the Cassini spacecraft mission to Saturn and Titan. An important scientific data set also exists for Jupiter, which Cassini flew past during a gravity assist maneuver in December 2000.

This Software Interface Specification (SIS) describes the format, content and generation of the CIRS Time Sequential Data Record (TSDR) and of the CIRS Spectral Image Cube Archive Volumes for all CIRS mission phases. Each volume corresponds to one month of acquisition with the DATA directory split into two subdirectories, TSDR and CUBE.

The DATA/TSDR area forms a single logical table which is composed of the following fragments (see Glossary) :

Data fragment types:

FRV	White light fringe voltages at 2 second intervals.
DIAG	diagnostic data regarding IFM usability.
GEO	position and orientation of the spacecraft at the observation time, relative to the earth, sun, primary body and major satellites.
IFGM	raw interferogram data.
IHSK	interpolated housekeeping data.
ISPM	calibrated spectra re-gridded in wavenumber.
OBS	observation parameters.
POI	pointing of each detector on the target body or bodies during the observation.
RIN	pointing of each detector relative to a ring target.
TAR	summary of targets in the FOV.

The DATA/CUBE directory contains the Spectral Image Cubes. It contains directories displaying the cube data using two different projection types, equirectangular and point perspective.

2.2 Scope

This archive volume SIS applies to all Cassini CIRS Time Sequential Data Records and to all Cassini CIRS Spectral Image Cubes.

2.3 Applicable Documents

"The CIRS Ground Data System", CIRS Team, NASA GSFC Code 693, 2000.

"Vanilla Manual: A guide for software and data users" (preliminary draft), Kelly Bender, ASU Astronomy Dept., 2000.

3 Archive Volume Contents

This section describes the contents of each volume directory.

3.1 ROOT Directory Contents

The following files are contained in the ROOT directory:

File Name	File Contents
AAREADME.TXT	Volume contents and format info in ASCII text format.
ERRATA.TXT	Cumulative listing of updates to all CIRS volumes published so far.
VOLDESC.CAT	Description of volume contents in a PDS format.

3.2 CALIB Directory Contents

CALINFO.TXT	ASCII description of the contents of this directory.
2000_nesr_fpX_NNNNcm-1.txt	Spectral NESR file, where 'X' is the focal plane number (1, 3, 4); and NNNN is the spectral resolution in cm^{-1} (e.g. 6p6 = 6.6).
2000_nesr_fpX_NNNNcm-1.lbl	PDS label for the above file.

3.3 CATALOG Directory Contents

The files in the CATALOG directory provide a top-level understanding of the Cassini Mission, spacecraft, instruments and data sets in the form of completed PDS catalog objects.

CATINFO.TXT	ASCII description of the contents of this directory.
CIRSREF.CAT	CIRS bibliographic references catalog object.
DATASET.CAT	Data set catalog object.
INST.CAT	Instrument catalog object
INSTHOST.CAT	Spacecraft catalog object.
MISSION.CAT	Mission catalog object.
PERSON.CAT	Personnel catalog object.
PROJREF.CAT	Project bibliographic references catalog object.

3.4 DOCUMENT Directory Contents

Documentation. Below are listed the most important documentation files. Others may be added as required. Refer to the DOCINFO.TXT file in the DOCUMENT directory for a complete listing.

CUBESIS.PDF	PDF version of Spectral Image Cube Data Product Software Interface Specification. The data product SIS describes the types of archive data produced by the instrument in each volume.
CUBESIS.TEX	LaTeX (ASCII text) version of CUBESIS.PDF.
CUBESIS.LBL	PDS label for CUBESIS.PDF and CUBESIS.TXT.
CIRS-USER-GUIDE.PDF	CIRS User Guide in PDF format.
CIRS-USER-GUIDE.LBL	PDS label for the CIRS User Guide.
DOCINFO.TXT	ASCII text description of the DOCUMENT directory.
DATASIS.PDF	PDF version of Time Sequential Record Data Product Software Interface Specification. The data product SIS describes the types of archive data produced by the instrument in each volume.
DATASIS.TEX	LaTeX (ASCII text) version of DATASIS.PDF.
DATASIS.LBL	PDS label for DATASIS.PDF and DATASIS.TXT.
VOLSIS.PDF	PDF version of this document, the Volume Organization SIS, which describes the directory layout of the archive volumes on the media.
VOLSIS.TEX	LaTeX (ASCII text) version of VOLSIS.PDF.
VOLSIS.LBL	PDS label for VOLSIS.PDF and VOLSIS.TXT.
vanilla_fields.asc	Comma-separated value table of vanilla table fields including their types, sizes, and brief descriptions.
CIRS_FOV_OVERVIEW.PDF	PDF version of a document describing in-flight measurements of the CIRS fields of view.
CIRS_FOV_OVERVIEW.TXT	ASCII text version of above. Figures will be in separate tiff files in this directory.

CIRS_FOV_OVERVIEW.LBL	PDS Label for CIRS_FOV_OVERVIEW.TXT.
cirs_cal_eqns.doc	Description of cirs calibration mathematics.
cirs_cal_eqns.pdf	PDF version of cirs_cal_eqns.doc.
cirs_cal_eqns.lbl	PDS Label for cirs_cal_eqns.doc.

Other miscellaneous graphic figures (ps, eps, tiff) and other objects in this directory may vary from cruise to tour. These will be described in the individual DOCINFO.TXT files on each archive data volume.

3.5 DATA Directory Contents

The DATA directory contains two subdirectories. The TSDR subdirectory contains the Time Sequential Data Records and the CUBE subdirectory contains the Spectral Image Cubes.

DATAINFO.TXT	ASCII description of the contents of this directory.
CUBE/	subdirectory containing the Spectral Image Cubes.
TSDR/	subdirectory containing the Time Sequential Data Records .

3.5.1 TSDR Directory Contents

The DATA/TSDR directory contains sub-directories, which contain the binary data. The top-level directory contents are:

TSDRINFO.TXT	ASCII description of the contents of this directory.
APODSPEC/	subdirectory containing calibrated, apodized spectra.
HSK_DATA/	subdirectory containing tabular housekeeping data.
NAV_DATA/	subdirectory containing geometry and pointing info.
SUSPECT_SPECTRA/	subdirectory containing calibrated spectra but of potentially highly reduced quality due to noise artifacts and/or unsupported focal plane temperatures.
UNCALIBR/	subdirectory containing uncalibrated interferograms, interpolated housekeeping data, observational parameters, and diagnostic data.

In these subdirectories are contained the actual data files. Typically, files with the `.DAT` and `.VAR` extensions are binary format data files in two parts, accessed by the Vanilla program. Hence the files `FILENAME.DAT` and `FILENAME.VAR` are two halves of a whole: the `.DAT` file is the fixed-length record part and the `.VAR` is the variable length record file.

The `FILENAME` is typically a 3 or 4 letter string followed by 8-digit number. The letter string identifies the type of information stored therein, and the 8-digit number `YYMMDDHH` gives the start date and time DD/MM/YY HH:00:00 of the period to which the data pertain.

Finally, every `.DAT` file is accompanied by a detached PDS label file (`.LBL`), containing ODL keyword definitions.

`DATASET.TXT`	Vanilla DATASET file (ASCII), listing the types of Vanilla files to search for in the directory.
`DATASET.LBL`	PDS label for DATASET.TXT.
`DIAG.FMT`	The format file contains the list of fields in the DIAG tables.
`DIAGyymmddhh.DAT`	fixed-length binary data records for DIAG diagnostic data fields.
`DIAGyymmddhh.LBL`	PDS label file.
`FRV.FMT`	The format file contains the list of fields in the FRV tables.
`FRVyymmddhh.DAT`	fixed-length binary data records for IFM fringe voltages.
`FRVyymmddhh.VAR`	variable-length binary data records associated with `FRVyymmddhh.DAT`.
`FRVyymmddhh.LBL`	PDS label file.
`GEO.FMT`	The format file contains the list of fields in the GEO tables.
`GEOyymmddhh.DAT`	fixed-length binary data records for spacecraft orientation relative to primary body, earth, sun, and moons.
`GEOyymmddhh.LBL`	PDS label file.
`IFGM.FMT`	The format file contains the list of fields in the IFGM tables.
`IFGMyymmddhh.DAT`	fixed-length binary data records for raw interferogram data.
`IFGMyymmddhh.VAR`	variable-length binary data records associated with `IFGMyymmddhh.DAT`.
`IFGMyymmddhh.LBL`	PDS label file.

IHSK.FMT	The format file contains the list of fields in the IHSK tables.
IHSKyymmddhh.DAT	fixed-length binary data records for housekeeping data interpolated onto the same time-steps as observations.
IHSKyymmddhh.LBL	PDS label file.
ISPM.FMT	The format file contains the list of fields in the ISPM tables.
ISPMyymmddhh.DAT	calibrated, re-sampled (interpolated) spectral data. After FFT transform, data as resampled onto a standard spectral grid.
ISPMyymmddhh.VAR	variable-length binary data records associated with ISPMyymmddhh.DAT.
ISPMyymmddhh.LBL	PDS label file.
OBS.FMT	The format file contains the list of fields in the OBS tables.
OBSyymmddhh.DAT	fixed-length binary data records for observation parameters.
OBSyymmddhh.LBL	PDS label file.
OISPM.FMT	The format file contains the list of fields in the OISPM tables.
OISPMyymmddhh.DAT	calibrated, re-sampled (interpolated) spectral data. After FFT transform, data as resampled onto a standard spectral grid. Note, these are of potentially highly reduced quality due to noise artifacts and/or unsupported focal plane temperatures. The "O" in OISPM means "other".
OISPMyymmddhh.VAR	variable-length binary data records associated with OISPMyymmddhh.DAT.
OISPMyymmddhh.LBL	PDS label file.
POI.FMT	The format file contains the list of fields in the POI tables.
POIyymmddhh.DAT	fixed-length binary data records for detector intercept location, orientation and other info on the target body. E.g. incident angle on planet, smear, and FOV filling factor.
POIyymmddhh.LBL	PDS label file.
RIN.FMT	The format file contains the list of fields in the RIN tables.
RINyymmddhh.DAT	fixed-length binary data records for detector intercept location,

	orientation and other info on rings.
RINyymmddhh.LBL	PDS label file.
TAR.FMT	The format file contains the list of fields in the TAR tables.
TARyymmddhh.DAT	fixed-length binary data records for target identification in the FOV of each detector.
TARyymmddhh.LBL	PDS label file.

Note on the DATASET files: the DATASET files are the backbone of the Vanilla system. Each DATASET file either points to data files within the directory, or to other directories, or both. See the *Vanilla Users Guide* for details.

3.5.2 CUBE Directory Contents

CUBEINFO.TXT	ASCII description of the contents of this directory.
EQUIRECTANULAR/	subdirectory containing cubes using an equirectangular projection.
POINT_PERSPECTIVE/	subdirectory containing cubes using a point perspective projection.
RING_POLAR/	subdirectory containing cubes using a polar projection for the rings observations.

3.6 EXTRAS Directory Contents

EXTRINFO.TXT	ASCII description of the contents of this directory.
CUBE_OVERVIEW/	subdirectory containing only two other directories.
EQUIRECTANGULAR/	subsubdirectory containing overviews of the equirectangular cubes.
POINT_PERSPECTIVE/	subsubdirectory containing overviews of the point perspective cubes.
RING_POLAR/	subsubdirectory containing overviews of the ring polar cubes.
SURFTEMP/TITAN/	Titan surface temperature maps.
VERTPROF/	Titan atmosphere temperature, aerosol, and ice profiles.

3.7 INDEX Directory Contents

INDEX directory contains:

CUBE_EQUI_CUMINDEX.TAB	Cumulative tabular summary of the CUBE/EQUIRECTANGULAR files in all volumes at the time of creation of this set.
CUBE_EQUI_CUMINDEX.LBL	PDS label describing CUBE_EQUI_CUMINDEX.TAB.
CUBE_EQUI_INDEX.TAB	Tabular summary of the CUBE/EQUIRECTANGULAR files in this volume.
CUBE_EQUI_INDEX.LBL	PDS label describing CUBE_EQUI_INDEX.TAB.
CUBE_POINT_CUMINDEX.TAB	Cumulative tabular summary of the CUBE/POINT_PERSPECTIVE files in all volumes at the time of creation of this set.
CUBE_POINT_CUMINDEX.LBL	PDS label describing CUBE_POINT_CUMINDEX.TAB.
CUBE_POINT_INDEX.TAB	Tabular summary of the CUBE/POINT_PERSPECTIVE files in this volume.
CUBE_POINT_INDEX.LBL	PDS label describing CUBE_POINT_INDEX.TAB.
CUBE_RING_CUMINDEX.TAB	Cumulative tabular summary of the CUBE/RING_POLAR files in all volumes at the time of creation of this set.
CUBE_RING_CUMINDEX.LBL	PDS label describing CUBE_RING_CUMINDEX.TAB.
CUBE_RING_INDEX.TAB	Tabular summary of the CUBE/RING_POLAR files in this volume.
CUBE_RING_INDEX.LBL	PDS label describing CUBE_RING_INDEX.TAB.
INDXINFO.TXT	ASCII description of the contents of this directory.
INDXINFO.LBL	PDS label for previous.
TSDR_CUMINDEX.TAB	Cumulative tabular summary of the data files in all volumes at the time of creation of this set.
TSDR_CUMINDEX.LBL	PDS label describing TSDR_CUMINDEX.TAB.
TSDR_INDEX.TAB	Tabular summary of the data files in this volume.
TSDR_INDEX.LBL	PDS label describing TSDR_INDEX.TAB.
XXXXXXXX_TOL.ASC	ASCII text file summarizing spacecraft activities in spacecraft activity sequence XXXXXXXX.

	An example cruise sequence is 'C22', or 'C23PHASEA'. An example tour sequence is 'S01'.
XXXXXXXX_TOL.LBL	PDS label describing XXXXXXXX_TOL.ASC.

3.8 SOFTWARE Directory Contents

SOFTWARE directory contains:

SOFTINFO.TXT	ASCII description of the contents of this directory.
SOFTINFO.LBL	PDS label for previous.
BIN	A directory containing binary executables for two operating systems, Linux and Solaris in sub-directories LINUX and SOLARIS.
DOC	A directory containing software documentation.
DOC/vanilla-guide.html	Users guide to the Vanilla data extraction tool in HTML format
DOC/vanilla-guide.pdf	PDF version of previous.
SRC	A directory containing C and PERL source code and Makefiles.

4 Archive Volume Format

4.1 Disk Format

None: there is no physical format produced by CIRS. Volumes will be sized to 4.2 GB, to fit on a DVD-ROM, which will be produced by PDS. An exception is the sample volume produced during the 2003 readiness review process, which is a 700 MB CD-ROM.

4.2 File Formats

4.2.1 Catalog File Format

`.CAT` files. Found in the `ROOT` and `CATALOG` directories. Object oriented structure: 'keyword = value'. All lines terminated with carriage return and line feed characters.

4.2.2 Document File Format

`.TXT` and `.PDF` suffixes. Found in all top-level directories. TXT-suffix files are ASCII files with embedded PDS labels. Lines are terminated with carriage return and line feed characters. PDF files are binary files written in the Portable Document Format, a proprietary format of Adobe Software Inc.

4.2.3 PDS Label Format

PDS labels are object-oriented structures consisting of 'keyword = value' statements. CIRS PDS labels are all detached from the subject file and placed in a separate label file (`.LBL` extension). Some special file types contain PDS labeling elements and therefore do not require labels: examples are `.CAT` and `.FMT` file types.

For a fuller description see [1].

Lines are terminated with the carriage return and linefeed characters.

4.2.4 Software File Format

Computer code is written in ANSI C. Executable binary files are precompiled for the Linux operating system 2.4 kernel on 32-bit Pentium 4 architecture, and Solaris 9 on Sun UltraSPARC 10 hardware.

4.2.5 Tabular File Format

File suffixes are `.TAB`, `.DAT` and `.VAR`. Files are either ASCII or binary.

ASCII files (`.TAB`) are found in the INDEX directory. These files are formatted for direct reading into many database management systems on various operating systems. Fields are enclosed by double quotes, and separated by commas. Character fields are left justified and padded to a constant length with spaces if required. Numeric fields are right justified. The 'start bytes' and 'bytes' values listed in the labels count data only, not quotes, commas or external spaces. The records are fixed length and terminated by the carriage return and line-feed characters.

Binary tables end in `.DAT` (fixed length data fields) and `.VAR` (variable length data fields), and are found in the `DATA` and `CALIB` directories. If a `.VAR` data file exists, it is always accompanied by a `.DAT` file, but the latter may exist alone. `.DAT` files contain pointers to data items in the associated variable field length data files.

5 Archive Volume Generation

5.1 Data Transfer, Validation Methods, and Production

The data volumes will be created at NASA GSFC by the CIRS team. These will be electronically transferred to the PDS Atmospheres Node at NMSU and the Science data Verification Team (SDVT) members for verification.

After verification, the data will be physically copied to DVD by the PDS atmospheres node, and physical copies will be sent to the NSSDC, the PDS Central Node, and one for the Atmospheres node. Other interested parties will be able to download the volumes from the Atmospheres Node.

5.2 Data Product Sizes

The amount of data returned per downlink will be extremely variable, depending on whether the instrument is taking data or not, and what data rate it is using.

Predicted average data rates are as follows:

Product	**per month (MB)**	**over 4-year tour (GB)**
DIAG	3.0	0.14
FRV	7.0	0.30
GEO	32.0	1.50
IFGM	500.0	24.00
IHSK	4.0	0.20
ISPM	2000.0	96.00
OBS	0.7	0.03
POI	250.0	12.0
RIN	200.0	9.6
TAR	6.0	0.3
Total	3003	144.1

Table 2: Predicted Data Volumes.

Note that these rates will vary substantially from month to month, depending on activities.

5.3 Labeling and Identification

An example dataset ID is CO-J-CIRS-2/4-TSDR-V1.0. The 'J' for Jupiter will become 'S' for Saturn after January 1st 2004. The version number will also be incremented as and when required.

Volume ID will be of the form: `COCIRS_xxxx`, where 'xxxx' is a four digit number beginning with 0001. Volumes will be numbered sequentially in chronologically order.

6 Cognizant Persons and Support Staff

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Table 3: Table of Cognizant Persons

7 References

[1] Planetary Data System Standards Reference Version 3.4, JPL D-7669 Part 2, June 15, 2001.