Cassini High Rate Detector (HRD)
Standard Data Products and Archive Volume

Software Interface Specification

Version 1.1 November 26, 2007

Carol Neese
Mark Sykes
Planetary Science Institute,
Tucson AZ 85719-2395

IO-AR-013

Cassini High Rate Detector (HRD)
Standard Data Products and Archive Volume

Software Interface Specification

Version 1.1
November 26, 2007

Approved:

____________________________________ ______________
Thanasis Economou Date
HRD Acting Principal Investigator

____________________________________ ______________
Elmain Martinez Date
Cassini Archive Data Engineer

____________________________________ ______________
Mike A’Hearn Date
PDS Small Bodies Node PI

Distribution List

M. A'Hearn
P. DiDonna
T. Economou
E. Martinez

Document Change Log

Change	Date	Affected Portions
Mark sample label as final rather than provisional	Nov. 26, 2007	Section 6

Acronyms and Abbreviations

ASCII	American Standard Code for Information Interchange
CDA	Cosmic Dust Analyser
CODMAC	Committee on Data Management and Computation
DA	Dust Analyser
DFMI	Dust Flux Monitor Instrument
DUCMA	Dust Counter and Mass Analyzer Instrument
HRD	High Rate Detector
JPL	Jet Propulsion Laboratory
NASA	National Aeronautics and Space Administration
OLAF	On-Line Archiving Facility
PDS	Planetary Data System
PI	Principal Investigator
PVDF	Polyvinylidene Fluoride
SBN	Small Bodies Node
SFDU	Standard Formatted Data Unit
SIS	Software Interface Specification
TBD	To Be Determined

Table of Contents

1. Introduction

1.1. Purpose and Scope

This document describes the format and the content of the Cassini High Rate Detector (HRD) products as archived in the Small Bodies Node (SBN) in the Planetary Data System (PDS). The data products stored in the PDS are a subset of the holdings of the CDA (Cosmic Dust Analyzer) team database in Heidelberg, Germany, and the archive is produced by the HRD team at the University of Chicago.

This Software Interface Specification (SIS) is intended to provide enough information to enable users to understand and use the HRD data products as stored in the PDS. The users for whom this SIS is intended are software developers of the programs used in generating the HRD products and scientists who will analyze the data, including those associated with the Cassini-Huygens Project and those in the general planetary science community.

1.2. Contents

The High Rate Detector (HRD) is an independent part of the Cosmic Dust Analyzer (CDA) instrument on the Cassini orbiter that studies the physical properties of dust particles hitting the detector. This Data Product SIS describes how the HRD instrument acquires its data, and how the data are processed. This document specifically discusses the high level data subset, which is stored in the PDS.

1.3. Applicable Documents and Constraints

This Data Product SIS is responsive to the following Cassini documents:

1 Cassini/Huygens Program Archive Plan for Science Data, PD 699-068.

The reader is referred to the following documents for additional information:

1 Planetary Data System Data Preparation Workbook and Standards Reference Version 3.7, JPL D-7669.
2 The Cassini Cosmic Dust Analyser, Srama et al., SSR Volume 114, p. 465-518, December 2004.

2. Data Product Characteristics

2.1. Instrument Overview

The High Rate Detector (HRD) is part of the Cosmic Dust Analyzer (CDA) on the Cassini mission payload. The overall objective of the HRD is to carry out quantitative measurements of particle flux and mass distribution throughout the Saturn ring system. The particle impact rate and particle mass distribution will be determined with respect to Saturnian distances, distance from the rings, and to magnetospheric coordinates. The particle mass range covered by the HRD (assuming a particle impact velocity of 15 km/s) ranges from $8x10^{-13}$ to $8x10^{-8}$ g for differential and cumulative flux measurements, and > $8x10^{-8}$ g for cumulative flux measurements.

The HRD was designed, built and tested at the University of Chicago and measures differential and cumulative particle fluxes. The HRD has a high counting rate capability (up to 10^4 random impacts/second with <5% corrections) which will be particularly important during Saturn ring plane crossings, where fluxes are large enough to saturate the counting rate of the DA (Dust analyzer) (~1 counts/sec).

The HRD has significant inheritance from the University of Chicago Dust Counter and Mass Analyzer instrument (DUCMA) flown earlier on the Vega-1 and Vega-2 spacecraft to Comet Halley (Perkins et al., 1985), and from the Dust Flux Monitor Instrument (DFMI) on the Stardust mission (Tuzzolino et al. 2003). The instrument employs the dust particle detection technique described by Simpson and Tuzzolino (1985) and consists of two polyvinylidene fluoride (PVDF) sensors with associated electronics. The sensors are mounted on the front of the HRD electronics box and the HRD detects individual particles impacting the PVDF sensors and provides continuous measurements of cumulative particle fluxes for particle masses greater than four mass thresholds for each of the two sensors.

The HRD is an independent instrument containing its own memory and processor. The only interface to the Dust Analyzer (DA) of the CDA is via the power and data cables. HRD power is supplied by the DA main electronics and data transfer responds by latching the appropriate data into the HRD data output register. The latching of the data generates an interrupt to DA indicating that the data is ready to be read by DA and stored into DA memory.

The HRD is rigidly mounted to the DA so that as the CDA turntable is rotated, the HRD scans different particle arrival directions. The HRD pointing is exactly the same as the DA pointing.

2.2. Data Products

The HRD data products are all ASCII (American Standard Code for Information Interchange) tables and include raw, processed, and calibration files. Also included in the archive are tables of instrument on-off times, and tables of hourly instrument pointing and spacecraft position. A sample data label for the processed files appears at the end of this document. This sample data label includes column definitions for each of the columns in the data tables. The format of the raw and calibration files is the same as that for the processed files, but without the final three columns which give a quality code and the threshold mass and particle diameter.

Raw files contain all events for the time period covered each file, including calibration and noise events. Each event in the raw files is assigned a unique event number. The calibration files contain the flight calibration events which have been extracted from the raw files. The processed files contain the events from the raw files with the calibration and noise events removed.

The file counts and sizes will be relatively small. The greatest data volume will occur in 2005 during the Saturn ring plane crossing, with 36 data files each less than 500 kb. Note that the HRD files after 2005-248 are somewhat increased in size because the larger PVDF sensor M was hit by a very big dust particle that resulted in a change to the lowest mass threshold (M1), causing the M1 counter to become somewhat noisier.

All data products and associated documentation will be generated by the HRD team. The PDS SBN will assist in the definition and development of first delivery products and their associated PDS documentation, which will act as templates for subsequent updates. When new products are developed by the HRD team, PDS SBN will likewise assist in the definition and development of those products and their associated PDS documentation in preparation for their initial delivery.

All the data products described by this SIS will be included in a single data set. Ongoing deliveries of data will be accomodated in cumulative versions of the data set, i.e. the latest version of the data set will include all the data archived so far, superseding earlier versions.

2.3. Data Processing

This documentation uses the "Committee on Data Management and Computation" (CODMAC) data level numbering system. The raw data files referred to in this document are considered "level 2" or "Edited Data" (equivalent to NASA level 0). The data files are generated from level 1 or "Raw Data" which is the telemetry packets within the project specific Standard Formatted Data Unit (SFDU) record. The processed files have added columns for mass and particle size determined from the calibration described in the instrument document, and are thus CODAMC level 3. Refer to Table 1.

Table 1. Processing Levels for Science Data Sets

NASA	CODMAC	Description
Packet data	Raw - Level 1	Telemetry data stream as received at the ground station, with science and engineering data embedded.
Level-0	Edited - Level 2	Instrument science data (e.g., raw voltages, counts) at full resolution, time ordered, with duplicates and transmission errors removed.
Level 1-A	Calibrated - Level 3	Level 0 data that have been located in space and may have been transformed (e.g., calibrated, rearranged) in a reversible manner and packaged with needed ancillary and auxiliary data (e.g., radiances with the calibration equations applied).
Level 1-B	Resampled - Level 4	Irreversibly transformed (e.g., resampled, remapped, calibrated) values of the instrument measurements (e.g., radiances, magnetic field strength).
Level 1-C	Derived - Level 5	Level 1A or 1B data that have been resampled and mapped onto uniform space-time grids. The data are calibrated (i.e., radiometrically corrected) and may have additional corrections applied (e.g., terrain correction).

Table 1. Processing Levels for Science Data Sets		
Level 2	Derived - Level 5	Geophysical parameters, generally derived from Level 1 data, and located in space and time commensurate with instrument location, pointing, and sampling.
Level 3	Derived - Level 5	Geophysical parameters mapped onto uniform space-time grids.

2.4 Calibration

The HRD calibrations are similar to those for the Dust Flux Monitor Instrument (DFMI) on the Stardust mission. The pre-flight calibrations were carried out with dust particle accelerators in Heidelberg and Munich. During the calibration at Heidelberg, iron particles in the velocity range of 1-12 km/sec were used, while at the Munich accelerator glass particles of a similar velocity range were used. The mass and particle diameters corresponding to each detector threshold as derived from these calibrations are given in the HRD instrument catalog file.

In addition to laboratory calibration, in-flight pulser calibrations are performed periodically to ascertain the performance of the electronic system of the HRD instrument. These in-flight calibration events are included in the raw data files and are also extracted to separate calibration files in the archive. If the thresholds are changed over the course of the mission, this will be documented in a threshold change log.

3. Archive Volumes

3.1. Generation

The HRD Data Product Archive Collection and its updates are produced by the HRD Instrument Team in cooperation with the Small Bodies Node (SBN) of the PDS. The Archive Collection will include data acquired during the Cruise phase as well as during the Tour.

The SBN and the HRD team will collaborate to design the PDS documentation (label, catalog, and index) files associated with the initial data delivery by the HRD team. SBN and the HRD team together will also identify how these files are to be updated in subsequent deliveries. This procedure will also be followed with new data products as they become available. The HRD team will include documentation files (and subsequent updates) with their deliveries. All data formats are based on the Planetary Data System standards as documented in the PDS Standards Reference.

SBN will generate the data labels and volume structure of the HRD archive using the On-Line Archiving Facility (OLAF). The HRD team will deliver data products to SBN in a form compatible with OLAF and with the archive design mutually agreed upon by SBN and the HRD team. Higher level products are not within the scope of this SIS but will be covered under a separate SIS and be delivered to SBN by the HRD team as standard data products through OLAF.

3.2. Data Transfer

Deliveries will be made to the PDS in accordance with the schedule defined in the Cassini/Huygens Program Archive Plan for Science Data, PD 699-068, as shown here:

From first day of:	Through last day of:	Delivery date:
Oct 1997	Mar 2006	(already delivered)
Apr 2006	Jun 2006	Apr. 1, 2007
July 2006	Sep 2006	Jul. 1, 2007
Oct 2006	Dec 2006	Oct. 1, 2007
Jan 2007	Mar 2007	Jan. 1 2008
Apr 2007	Jun 2007	Apr. 1 2008
Jul 2007	Sep 2007	Jul. 1, 2008
Oct 2007	Jul 2008	Sep. 1, 2008

3.3. Review and Revision

The archive validation procedure described in this section applies to volumes generated during all phases of the mission. All data archived by the PDS are validated by use of the PDS peer review procedures.

The data and documentation will be subject to PDS internal review followed by an external peer review. The external review consists of at least two scientists having interest in the products being generated by the HRD who are associated with neither the HRD team nor the PDS. Reviewers are selected by the PDS with input from the HRD team.

In the event that the contents of a volume are found to contain errors, the reviewers can recommend one of two courses of action: fix the files or publish as is with a note in the ERRATA.TXT file. If the errors are minor, typically minor errors in the documentation, the volume can be published if the appropriate notes added to the volume's errata file and the error(s) are corrected on subsequent volumes. If the errors are major, typically involving errors in the data themselves, the corrections constitute liens against the data set that must be resolved before the data set can be ingested by the PDS. In that event, the volume must be corrected and regenerated by the HRD team.

3.4. Data Volume Architecture

Data will be delivered on DVD or DVD-image with the following directory architecture:

```
VOLUME_ID ----------AAREADME.TXT , VOLDESC.CAT, ERRATA.TXT
                |
                |--/DATA       [this directory contains all data products and their labels.]
                     |
                     |--/raw  [raw data files]
                     |--/calibrate  [calibration files]
```

```
        |--/processed  [processed files]
        |--/onoff  [instrument on-off times]
        |--/pointing  [instrument pointing and s/c positions]
|
|--/CATALOG [this directory contains the data set, instrument,
|                    and mission catalog files.]
|
|--/INDEX [this directory contains the index files for the volume.]
|
|--/DOCUMENT [this directory contains the document you are reading.]
```

4. Cognizant Persons

Table 4.1 – HRD PDS Archive Collection Support Staff

HRD Team			
Dr. Thanasis Economou	Laboratory for Astrophysics and Space Research University of Chicago 933 East 56th Street Chicago IL 60637	773/702-7829	tecon@tecon.uchicago.edu
Mr. Pasquale DiDonna	Laboratory for Astrophysics and Space Research University of Chicago 933 East 56th Street Chicago IL 60637	773/834-3774	pdidonna@ucec.uchicago.edu
Asteroid/Dust Subnode of the SBN, Planetary Science Institute			
Dr. Carol Neese	Planetary Science Institute 1700 East Ft. Lowell, Suite 106 Tucson, AZ 85719-2395	520/622-6300	neese@psi.edu
PDS Engineering Node			
Steven Adams, PDS Cassini Data Engineer	Jet Propulsion Laboratory, MS Pasadena, CA	818/354-2624	Steven.L.Adams@jpl.nasa.gov

5. References

Perkins, M.A., J.A. Simpson, and A.J. Tuzzolino. Cometary and Interplanetary Dust Experiment on the Vega Spacecraft Mission to Halley's Comet. *Nucl. Instr. and Methods in Phys. Res.*, **A239**, 310. 1985.

Simpson, J.A. and A.J. Tuzzolino. Polarized Polymer Films as Electronic Pulse Detectors of Cosmic Dust Particles. *Nucl. Instr. and Methods in Phys. Res.* **A236**, 187-202, 1985.

Srama, R., T.J. Ahrens, N. Altobelli, S. Auer, J.G. Bradley, and 35 others. The Cassini Cosmic Dust Analyzer. *Space Science Reviews* **114**, 465-518, 2004.

Tuzzolino, A.J., T.E. Economou, R.B. McKibben, J.A. Simpson, J.A.M. McDonnell, and 6 others. The Dust Flux Monitor Instrument for the *STARDUST* Mission to Comet Wild-2. *Geophys. Res*. **108**, no. 12, doi:10.1029/2003JE002019, 2003.

6. Sample HRD Product Label

```
PDS_VERSION_ID                   = PDS3

RECORD_TYPE                      = "FIXED_LENGTH"
RECORD_BYTES                     = 161
FILE_RECORDS                     = 6

^TABLE                           = "hrd_2003_037_111_prc.tab"

DATA_SET_ID                      = "CO-D-HRD-3-COHRD-V1.0"
PRODUCT_NAME                     = "HRD_2003_037_111_PRC"
PRODUCT_ID                       = "PROCESSED_2003_HRD_2003_037_111_PRC_TAB"
INSTRUMENT_HOST_ID               = "CO"
INSTRUMENT_HOST_NAME             = "CASSINI ORBITER"
INSTRUMENT_ID                    = "HRD"
INSTRUMENT_NAME                  = "HIGH RATE DETECTOR"
TARGET_NAME                      = "DUST"
TARGET_TYPE                      = "DUST"
START_TIME                       = 2003-037T22:22:18.329
STOP_TIME                        = 2003-111T09:51:05.968
PRODUCT_CREATION_TIME            = 2007-01-31  /* File uploaded to OLAF */
REFERENCE_KEY_ID                 = "SRAMAETAL2004"

OBJECT                           = TABLE
 ROWS                            = 6
 ROW_BYTES                       = 161
 INTERCHANGE_FORMAT              = "ASCII"
 COLUMNS                         = 28
 DESCRIPTION                     = "Processed Cassini HRD data file.  Data
       files in the 'processed' subdirectory have had calibration events and
       noisy events removed.  On 2005-248 there occurred an M4 event in the
       large detector which resulted in a noisy M1 threshold.  Since then,
       all M1 events are considered to be noise and have been removed from
       the processed data unless the M2 threshold is triggered or the small
       detector m1 threshold is triggered or the large detector High Mass is
       set.  The processed files have filenames of the form
       hrd_yyyy_doy_doy_prc.tab and include data within the date range
       specified."

 OBJECT                          = COLUMN
  COLUMN_NUMBER                  = 1
  NAME                           = "EVENT_CODE"
  DESCRIPTION                    = "A unique code assigned to each event in
       the raw data files to enable tracking an event through the calibration
       and processed files.  The event code has a range from A1-Z999999999.
       The letter corresponds to the year such that A events are in 2000, B
       events in 2001, etc.  The numbers are sequential starting with 1
       within the year.  The same event listed in the processed or
       calibration files will have the same event code."
  DATA_TYPE                      = "CHARACTER"
  START_BYTE                     = 1
  BYTES                          = 10
  FORMAT                         = "A10"
 END_OBJECT                      = COLUMN

 OBJECT                          = COLUMN
  COLUMN_NUMBER                  = 2
  NAME                           = "EVC"
  DESCRIPTION                    = "The event counter (EVC) generated by the
       HRD data processing software is a 3 digit integer with a range of 0 to
       256. When the data processing software finds an A5A5A5 sync pattern or
       the counter is greater than 256, the counter is reset to 0."
```

```
 DATA_TYPE                        = "ASCII_INTEGER"
 START_BYTE                       = 12
 BYTES                            = 3
 FORMAT                           = "I3"
END_OBJECT                        = COLUMN

OBJECT                            = COLUMN
 COLUMN_NUMBER                    = 3
 NAME                             = "SYC"
 DESCRIPTION                      = "The HRD Sync (SYC) consists of 3 bytes
       which contain A5A5A5 or EVEVEV.  A5A5A5 indicates the start of an HRD
       Cruise Mode or Encounter Mode header, and EVEVEV indicates a discrete
       event.  A5A5A5 is part of the HRD data, while EVEVEV is generated by
       the HRD data processing software to indicate a discrete event."
 DATA_TYPE                        = "CHARACTER"
 START_BYTE                       = 16
 BYTES                            = 6
 FORMAT                           = "A6"
END_OBJECT                        = COLUMN

OBJECT                            = COLUMN
 COLUMN_NUMBER                    = 4
 NAME                             = "TP"
 DESCRIPTION                      = "The HRD temperature indicator (TP) has a
       range from 0 to 99.  The temperature is read by the Dust Analyzer (DA)
       instrument and given to HRD.  The formula to convert the temperature
       code (TP) into degree Celsius is Temp = 40 - TP * 0.5.  Example: A TP
       value of 63 results in a Temperature of -8.5 degC."
 DATA_TYPE                        = "ASCII_INTEGER"
 START_BYTE                       = 23
 BYTES                            = 2
 FORMAT                           = "I2"
END_OBJECT                        = COLUMN

OBJECT                            = COLUMN
 COLUMN_NUMBER                    = 5
 NAME                             = "STAT"
 DESCRIPTION                      = "The hex code for the eight bit status
       word has two bytes, the first corresponding to binary status word bits
       4-7 and the second corresponding to status word bits 0-3.  Since
       status word bits 4 and 5 are always zero, the first hex byte has only
       four possibilities:

       First       SW bits
       hex byte:   7654:   Description:
              0    0000    D1 and D2 Threshold set to High Mass
              4    0100    D1 Threshold set to Low Mass and D2
                                 Threshold set to High Mass
              8    1000    D1 Threshold set to High Mass and D2
                                 Threshold set to Low Mass
              C    1100    D1 and D2 Thresholds set to Low Mass

       The second hex byte corresponds to binary status word bits 0-3 as
       follows:

       Second     SW bits
       hex byte:  3210:    Description:
       0          0000    Cruise Mode
       1          0001    .1 sec Encounter Mode time resolution
       2          0010    .2 sec Encounter Mode time resolution
       3          0011    .3 sec Encounter Mode time resolution
       4          0100    .4 sec Encounter Mode time resolution
       5          0101    .5 sec Encounter Mode time resolution
       6          0110    .6 sec Encounter Mode time resolution
```

```
       7          0111    .7 sec Encounter Mode time resolution
       8          1000    .8 sec Encounter Mode time resolution
       9          1001    .9 sec Encounter Mode time resolution
       A          1010     1 sec Encounter Mode time resolution
       B          1011     Gain 1 In-Flight Calibration
       C          1100     Gain 2 In-Flight Calibration
       D          1101     Gain 3 In-Flight Calibration
       E          1110     Gain 4 In-Flight Calibration

       Example:  If hex status word is C0, binary status word bits 4-7 are C
       = 1100 and binary status word bits 0-3 are 0 = 0000.  Consulting the
       table, the D1 and D2 Thresholds are set to Low Mass, and the status is
       Cruise Mode."
  DATA_TYPE                         = "CHARACTER"
  START_BYTE                        = 26
  BYTES                             = 2
  FORMAT                            = "A2"
 END_OBJECT                         = COLUMN

 OBJECT                             = COLUMN
  COLUMN_NUMBER                     = 6
  NAME                              = "OBS_TIME"
  DESCRIPTION                       = "Universal Time Coordinated (UTC) of the
       SC/CLK time"
  DATA_TYPE                         = "TIME"
  START_BYTE                        = 29
  BYTES                             = 21
  FORMAT                            = "A21"
 END_OBJECT                         = COLUMN

 OBJECT                             = COLUMN
  COLUMN_NUMBER                     = 7
  NAME                              = "SC_CLK"
  DESCRIPTION                       = "The 32-bit spacecraft clock (SC_CLK)
       only appears in the 32-byte HRD cruise mode header.  It has a range of
       0 - 4294967295 seconds.  When HRD receives the spacecraft clock from
       the Dust Analyzer (DA) instrument, HRD stores the spacecraft clock and
       the HRD 32-bit header clock at the same time.  This insures that the
       two clocks are in sync with each other."
  DATA_TYPE                         = "ASCII_INTEGER"
  START_BYTE                        = 51
  BYTES                             = 10
  FORMAT                            = "I10"
 END_OBJECT                         = COLUMN

 OBJECT                             = COLUMN
  COLUMN_NUMBER                     = 8
  NAME                              = "HD_CLK"
  DESCRIPTION                       = "The HRD header clock (HD_CLK) appears in
       the 32-byte HRD cruise mode header or the 24-byte encounter mode
       header.  When HRD is in cruise mode, the clock is 32 bits long and has
       a range of 0 - 4294967295 seconds.  If HRD is in encounter mode, the
       clock is 27 bits long and has a range of 0 - 134217727 seconds.  In
       cruise mode the header clock is only updated when HRD receives the
       spacecraft time.  If HRD is in encounter mode then the clock is
       updated for every encounter mode read out.  On HRD power on the HD/CLK
       is set to zero."
  DATA_TYPE                         = "ASCII_INTEGER"
  START_BYTE                        = 62
  BYTES                             = 10
  FORMAT                            = "I10"
 END_OBJECT                         = COLUMN

 OBJECT                             = COLUMN
```

```
 COLUMN_NUMBER                   = 9
 NAME                            = "CLK"
 DESCRIPTION                     = "The HRD 21-bit clock (CLK) has a range
       of  0 - 2097151 seconds.  If SYC is A5A5A5, this column shows the
       first 21 bits of HD_CLK, and if SYC is EVEVEV it shows the 21-bit
       clock from the discrete event.  The HD/CLK and CLK are generated by
       the same time source on the HRD instrument.  The only difference is
       that the HD/CLK is stored when HRD receives the spacecraft clock and
       the CLK is stored when a dust particle impact is recorded."
 DATA_TYPE                       = "ASCII_INTEGER"
 START_BYTE                      = 73
 BYTES                           = 7
 FORMAT                          = "I7"
END_OBJECT                       = COLUMN

OBJECT                           = COLUMN
 COLUMN_NUMBER                   = 10
 NAME                            = "BIG_M1"
 DESCRIPTION                     = "Large detector M1 threshold is either 1
       or 0.  1 indicates that the M1 threshold latch has been triggered.
       Every time the threshold is exceeded, this will be indicated in the
       CM1 counter (BIG_CM1)."
 DATA_TYPE                       = "ASCII_INTEGER"
 START_BYTE                      = 81
 BYTES                           = 1
 FORMAT                          = "I1"
END_OBJECT                       = COLUMN

OBJECT                           = COLUMN
 COLUMN_NUMBER                   = 11
 NAME                            = "BIG_M2"
 DESCRIPTION                     = "Large detector M2 threshold is either 1
       or 0.  1 indicates that the M2 threshold latch has been triggered. For
       M2 to trigger, M1 must be triggered.  Every time the threshold is
       exceeded, this will be indicated in the CM2 counter (BIG_CM2)."
 DATA_TYPE                       = "ASCII_INTEGER"
 START_BYTE                      = 83
 BYTES                           = 1
 FORMAT                          = "I1"
END_OBJECT                       = COLUMN

OBJECT                           = COLUMN
 COLUMN_NUMBER                   = 12
 NAME                            = "BIG_M3"
 DESCRIPTION                     = "Large detector M3 threshold is either 1
       or 0.  1 indicates that the M3 threshold latch has been triggered. For
       M3 to trigger, M1 and M2 must be triggered.  Every time the threshold
       is exceeded, this will be indicated in the CM3 counter (BIG_CM3)."
 DATA_TYPE                       = "ASCII_INTEGER"
 START_BYTE                      = 85
 BYTES                           = 1
 FORMAT                          = "I1"
END_OBJECT                       = COLUMN

OBJECT                           = COLUMN
 COLUMN_NUMBER                   = 13
 NAME                            = "BIG_M4"
 DESCRIPTION                     = "Large detector M4 threshold is either 1
       or 0.  1 indicates that the M4 threshold latch has been triggered. For
       M4 to trigger, M1, M2, and M3 must be triggered.  Every time the
       threshold is exceeded, this will be indicated in the CM4 counter
       (BIG_CM4)."
 DATA_TYPE                       = "ASCII_INTEGER"
 START_BYTE                      = 87
```

```
 BYTES                            = 1
 FORMAT                           = "I1"
END_OBJECT                        = COLUMN

OBJECT                            = COLUMN
 COLUMN_NUMBER                    = 14
 NAME                             = "SMALL_M1"
 DESCRIPTION                      = "Small detector m1 threshold is either 1
       or 0.  1 indicates that the m1 threshold latch has been triggered.
       Every time the threshold is exceeded, this will be indicated in the
       Cm1 counter (SMALL_CM1)."
 DATA_TYPE                        = "ASCII_INTEGER"
 START_BYTE                       = 89
 BYTES                            = 1
 FORMAT                           = "I1"
END_OBJECT                        = COLUMN

OBJECT                            = COLUMN
 COLUMN_NUMBER                    = 15
 NAME                             = "SMALL_M2"
 DESCRIPTION                      = "Small m2 threshold is either 1 or 0.  1
       indicates that the m2 threshold latch has been triggered.  For m2 to
       trigger, m1 must be triggered.  Every time the threshold is exceeded,
       this will be indicated in the Cm2 counter (SMALL_CM2)."
 DATA_TYPE                        = "ASCII_INTEGER"
 START_BYTE                       = 91
 BYTES                            = 1
 FORMAT                           = "I1"
END_OBJECT                        = COLUMN

OBJECT                            = COLUMN
 COLUMN_NUMBER                    = 16
 NAME                             = "SMALL_M3"
 DESCRIPTION                      = "Small m3 threshold is either 1 or 0.  1
       indicates that the m3 threshold latch has been triggered.  For m3 to
       trigger, m1 and m2 must be triggered.  Every time the threshold is
       exceeded, this will be indicated in the Cm3 counter (SMALL_CM3)."
 DATA_TYPE                        = "ASCII_INTEGER"
 START_BYTE                       = 93
 BYTES                            = 1
 FORMAT                           = "I1"
END_OBJECT                        = COLUMN

OBJECT                            = COLUMN
 COLUMN_NUMBER                    = 17
 NAME                             = "SMALL_M4"
 DESCRIPTION                      = "Small m4 threshold is either 1 or 0.  1
       indicates that the m4 threshold latch has been triggered.  For m4 to
       trigger, m1, m2, and m3 must be triggered.  Every time the threshold
       is exceeded, this will be indicated in the Cm4 counter (SMALL_CM4)."
 DATA_TYPE                        = "ASCII_INTEGER"
 START_BYTE                       = 95
 BYTES                            = 1
 FORMAT                           = "I1"
END_OBJECT                        = COLUMN

OBJECT                            = COLUMN
 COLUMN_NUMBER                    = 18
 NAME                             = "BIG_CM1"
 DESCRIPTION                      = "Large detector D1 threshold M1 16 bit
       counter has a range of 0 - 65535.  When there is a dust particle event
       above threshold the CM1 counter will be incremented and will roll over
       to 0 when the maximum count is reached.  The content of the counter is
       only updated when the A5A5A5 sync pattern occurs in SYC."
```

```
 DATA_TYPE                        = "ASCII_INTEGER"
 START_BYTE                       = 97
 BYTES                            = 5
 FORMAT                           = "I5"
END_OBJECT                        = COLUMN

OBJECT                            = COLUMN
 COLUMN_NUMBER                    = 19
 NAME                             = "BIG_CM2"
 DESCRIPTION                      = "Large detector D1 threshold M2 16 bit
       counter has a range of 0 - 65535.  When there is a dust particle event
       above threshold the CM2 counter will be incremented and will roll over
       to 0 when the maximum count is reached.  The content of the counter is
       only updated when the A5A5A5 sync pattern occurs in SYC."
 DATA_TYPE                        = "ASCII_INTEGER"
 START_BYTE                       = 103
 BYTES                            = 5
 FORMAT                           = "I5"
END_OBJECT                        = COLUMN

OBJECT                            = COLUMN
 COLUMN_NUMBER                    = 20
 NAME                             = "BIG_CM3"
 DESCRIPTION                      = "Large detector D1 threshold M3 16 bit
       counter has a range of 0 - 65535.  When there is a dust particle event
       above threshold the CM3 counter will be incremented and will roll over
       to 0 when the maximum count is reached.  The content of the counter is
       updated when the A5A5A5 sync pattern occurs in SYC."
 DATA_TYPE                        = "ASCII_INTEGER"
 START_BYTE                       = 109
 BYTES                            = 5
 FORMAT                           = "I5"
END_OBJECT                        = COLUMN

OBJECT                            = COLUMN
 COLUMN_NUMBER                    = 21
 NAME                             = "BIG_CM4"
 DESCRIPTION                      = "Large detector D1 threshold M4 16 bit
       counter has a range of 0 - 65535.  When there is a dust particle event
       above threshold the CM4 counter will be incremented and will roll over
       to 0 when the maximum count is reached. The content of the counter is
       updated when the A5A5A5 sync pattern occurs in SYC."
 DATA_TYPE                        = "ASCII_INTEGER"
 START_BYTE                       = 115
 BYTES                            = 5
 FORMAT                           = "I5"
END_OBJECT                        = COLUMN

OBJECT                            = COLUMN
 COLUMN_NUMBER                    = 22
 NAME                             = "SMALL_CM1"
 DESCRIPTION                      = "Small detector D2 threshold m1 16 bit
       counter has a range of 0 - 65535.  When there is a dust particle event
       above threshold the Cm1 counter will be incremented and will roll over
       to 0 when the maximum count is reached.  The content of the counter is
       only updated when the A5A5A5 sync pattern occurs in SYC."
 DATA_TYPE                        = "ASCII_INTEGER"
 START_BYTE                       = 121
 BYTES                            = 5
 FORMAT                           = "I5"
END_OBJECT                        = COLUMN

OBJECT                            = COLUMN
 COLUMN_NUMBER                    = 23
```

```
 NAME                             = "SMALL_CM2"
 DESCRIPTION                      = "Small detector D2 threshold m2 16 bit
       counter has a range of 0 - 65535.  When there is a dust particle event
       above threshold the Cm2 counter will be incremented and will roll over
       to 0 when the maximum count is reached.  The content of the counter is
       only updated when the A5A5A5 sync pattern occurs in SYC."
 DATA_TYPE                        = "ASCII_INTEGER"
 START_BYTE                       = 127
 BYTES                            = 5
 FORMAT                           = "I5"
END_OBJECT                        = COLUMN

OBJECT                            = COLUMN
 COLUMN_NUMBER                    = 24
 NAME                             = "SMALL_CM3"
 DESCRIPTION                      = "Small detector D2 threshold m3 16 bit
       counter has a range of 0 - 65535.  When there is a dust particle event
       above threshold the Cm3 counter will be incremented and will roll over
       to 0 when the maximum count is reached.  The content of the counter is
       only updated when the A5A5A5 sync pattern occurs in SYC."
 DATA_TYPE                        = "ASCII_INTEGER"
 START_BYTE                       = 133
 BYTES                            = 5
 FORMAT                           = "I5"
END_OBJECT                        = COLUMN

OBJECT                            = COLUMN
 COLUMN_NUMBER                    = 25
 NAME                             = "SMALL_CM4"
 DESCRIPTION                      = "Small detector D2 threshold m4 16 bit
       counter has a range of 0 - 65535.  When there is a dust particle event
       above threshold the Cm4 counter will be incremented and will roll over
       to 0 when the maximum count is reached.  The content of the counter is
       only updated when the A5A5A5 sync pattern occurs in SYC."
 DATA_TYPE                        = "ASCII_INTEGER"
 START_BYTE                       = 139
 BYTES                            = 5
 FORMAT                           = "I5"
END_OBJECT                        = COLUMN

OBJECT                            = COLUMN
 COLUMN_NUMBER                    = 26
 NAME                             = "QUALITY_CODE"
 DESCRIPTION                      = "The quality code indicates a discrepancy
       with the data line and is set to * if any one of the following obtain:
       1.  Missing latch data. 2.  Counters change with no latch data. 3.
       Higher threshold triggered and lower threshold did not.  The value of
       - indicates the quality code is not set and the above criteria do not
       apply."
 DATA_TYPE                        = "CHARACTER"
 START_BYTE                       = 145
 BYTES                            = 1
 FORMAT                           = "A1"
END_OBJECT                        = COLUMN

OBJECT                            = COLUMN
 COLUMN_NUMBER                    = 27
 NAME                             = "THRESHOLD_MASS"
 DESCRIPTION                      = "The particle mass corresponding to the
       detector threshold triggered for this event for an impact speed of 15
       km/sec, taken from Table 11 of [SRAMAETAL2004].  This table is
       reproduced in Table 1 of the HRD instrument catalog file in this data
       set."
 UNIT                             = "GRAM"
```

```
   DATA_TYPE                       = "ASCII_REAL"
   START_BYTE                      = 147
   BYTES                           = 7
   FORMAT                          = "E7.1"
   MISSING_CONSTANT                = 0.0E+00
  END_OBJECT                       = COLUMN

  OBJECT                           = COLUMN
   COLUMN_NUMBER                   = 28
   NAME                            = "THRESHOLD_DIAMETER"
   DESCRIPTION                     = "The particle diameter corresponding to
         the THRESHOLD_MASS assuming a particle density of 2.5 g/cm^3.  The
         values are taken from Table 11 of [SRAMAETAL2004].  This table is
         reproduced in Table 1 of the HRD instrument catalog file in this data
         set."
   UNIT                            = "MICRON"
   DATA_TYPE                       = "ASCII_REAL"
   START_BYTE                      = 155
   BYTES                           = 5
   FORMAT                          = "F5.1"
   MISSING_CONSTANT                = -99.9
  END_OBJECT                       = COLUMN

 END_OBJECT                        = TABLE
 END
```