Lunar Reconnaissance Orbiter
Cosmic Ray Telescope for the Effects of Radiation

CRaTER Standard Product
Data Record and Archive Volume
Software Interface Specification

Document 32–01211
Revision C
November 15, 2007

Prepared by

Peter G. Ford
MIT Kavli Institute
Cambridge, MA 02139, USA

Steven P. Joy
University of California
Los Angeles, CA 90095-1567, USA

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Release C
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Approved:

______________________________ __________
Harlan Spence Date
CRaTER Principal Investigator

______________________________ __________
Raymond Walker Date
PDS PPI Node Manager

Concurrence:

______________________________ __________
Stan Scott Date
LRO Data Engineer

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1 Preface

This document describes the format and content of the Lunar Reconnaissance Orbiter (LRO) Cosmic Ray Telescope for the Effects of Radiation (CRaTER) Standard Product Data Record archive.

1.1 Distribution list

Table 1: Distribution list

Name	Organization	Email
Charles Acton	JPL/PDS/NAIF	Charles.Acton@jpl.nasa.gov
Arlin Bartels	GSFC/LRO	Arlin.Bartels@nasa.gov
David Bradford	BU/CAS	bradford@bu.edu
Rick Foster	MIT/MKI	rickf@space.mit.edu
Robert Goeke	MIT/MKI	goeke@space.mit.edu
Mike Golightly	BU/CAS	mgolight@bu.edu
Nicholas Gross	BU/Astro	gross@bu.edu
Steve Johnson	JSC/SRAG	asjohnso@ems.jsc.nasa.gov
Steve Joy	UCLA/PDS/PPI	sjoy@igpp.ucla.edu
Justin Kasper	Harvard/SAO	jkasper@cfa.harvard.edu
Richard Saylor	GSFC/LRO	Richard.Saylor@gsfc.nasa.gov
Stanley R. Scott	GSFC/LRO	Stanley.R.Scott@nasa.gov
Edward J. Semones	JSC/SF	edward.j.semones@nasa.gov
Mark Sharlow	UCLA/PDS/PPI	msharlow@igpp.ucla.edu
Harlan Spence	BU/Astro	spence@bu.edu
Ray Walker	UCLA/PDS/PPI	rwalker@igpp.ucla.edu

1.2 Document change log

Table 2: Document change log

Change	Date	Affected portion
Initial draft	03/31/2007	All
Release A	05/31/2007	All
Release B (for peer review)	08/01/2007	All
Release C	11/15/2007	All

1.3 TBD items

Table 3 lists items that are not yet finalized.

Table 3: List of TBD items

Item	Section(s)	Page(s)
Names of NAIF-supplied products	Table 7, Table 19	7, 19

1.4 Abbreviations

Table 4: Abbreviations and their meaning

Abbreviation	Meaning
ASCII	American Standard Code for Information Interchange
BU	Boston University
CAS	College of Arts and Sciences (BU)
CD-ROM	Compact Disc – Read-Only Memory
CDR	Calibrated Data Record
CK	C-matrix Kernel (NAIF orientation data)
CRaTER	Cosmic Ray Telescope for the Effects of Radiation
CRC	Cyclic Redundancy Check
DAP	Data Analysis Product
DDR	Derived Data Record
DNA	Deoxyribonucleic Acid
DVD	Digital Versatile Disc
DVD-R	DVD - Recordable media
E&PO	Educational and Public Outreach
EDR	Experiment Data Record
SPDR	Standard Product (Experiment and Pipeline) Data Record
FOV	Field of View
FTP	File Transfer Protocol
GB	Gigabyte(s)
GCR	Galactic Cosmic Ray
GSFC	Goddard Space Flight Center
HK	Housekeeping
HTML	Hypertext Markup Language
ICD	Interface Control Document
ISO	International Standards Organization
JPL	Jet Propulsion Laboratory
JSC	Johnson Spaceflight Center
LET	Lineal Energy Transport
LRO	Lunar Reconnaissance Orbiter
MB	Megabyte(s)
MIT	Massachusetts Institute of Technology
MKI	MIT Kavli Institute for Astrophysics and Space Research
MOC	(Missions Operations Center (GSFC, LRO)
NAIF	Navigation and Ancillary Information Facility (JPL)
NASA	National Aeronautics and Space Administration
NSSDC	National Space Science Data Center
ODL	Object Description Language
PCK	Planetary Cartographic and Physical Constants Kernel (NAIF)

PDS	Planetary Data System
PPI	Planetary Plasma Interactions Node (PDS)
SCET	Spacecraft Event Time
SCLK	Spacecraft Clock
SIS	Software Interface Specification
SPE	Solar Particle Event
SPICE	Spacecraft, Planet, Instrument, C-matrix, and Events (NAIF data format)
SPK	SPICE (ephemeris) Kernel (NAIF)
SRAG	Space Radiation Analysis Group (JSC)
TBC	To Be Confirmed
TBD	To Be Determined
TEP	Tissue Equivalent Plastic

1.5 Glossary

Archive – An archive consists of one or more data sets along with all the documentation and ancillary information needed to understand and use the data. An archive is a logical construct independent of the medium on which it is stored.

Archive Volume – A volume is a unit of media on which data products are stored; for example, one DVD-R. An *archive volume* is a volume containing all or part of an archive; that is, data products plus documentation and ancillary files.

Archive Volume Set – When an archive spans multiple volumes, they are called an *archive volume set*. Usually the documentation and some ancillary files are repeated on each volume of the set, so that a single volume can be used alone.

Catalog Information – High-level descriptive information about a data set (e.g. mission description, spacecraft description, instrument description), expressed in Object Description Language (ODL), which is suitable for loading into a PDS catalog.

Data Product – A labeled grouping of data resulting from a scientific observation, usually stored in one file. A product label identifies, describes, and defines the structure of the data. An example of a data product is a planetary image, a spectral table, or a time series table.

Data Set – A data set is an accumulation of data products together with supporting documentation and ancillary files.

Experiment Data Record – An accumulation of raw output data from a science instrument, in chronological order, with duplicate records removed, together with supporting documentation and ancillary files.

Pipeline Data Record – An accumulation of calibrated data from a science instrument, derived from experiment data records, together with supporting documentation, calibration data, and ancillary files.

Standard Data Product – A data product generated in a predefined way using well-understood procedures, processed in "pipeline" fashion. Data products that are generated in a non-standard way are sometimes called *special data products*.

2 Introduction

2.1 SIS content overview

This software interface specification (SIS) describes the format, content, and generation of the CRaTER experiment and pipeline data record archive volumes. Section 3 describes the procedure for transferring data products to archive media. Section 4 describes the structure of the archive volumes and the contents of each file. Section 5 describes the file formats used on the archive volumes. Finally, Section Appendix A lists the individuals responsible for generating the archive volumes.

2.2 CRaTER scientific overview

The investigation hardware consists of a single, integrated sensor and electronics box with simple electronic and mechanical interfaces to the LRO spacecraft. The CRaTER sensor front-end design is based on standard stacked-detector, cosmic ray telescope systems that have been flown for decades, using detectors developed for other NASA flight programs. The analog electronics design is virtually identical to the robust and flight-proven design of the NASA/POLAR Imaging Proton Spectrometer that has been operating flawlessly on orbit since 1996. The digital processing unit is a simple and straightforward design also based on similar instruments with excellent spaceflight heritage. No new technology developments or supporting research are required for the final design, fabrication, and operation of this instrument.

The CRaTER telescope consists of six ion-implanted silicon detectors, mounted on detector boards, and separated by pieces of tissue-equivalent plastic, hereinafter referred to as TEP. All six of the silicon detectors are 35mm in diameter. Detectors 1, 3, and 5 are 140µm thick; the others are 1000µm thick. TEP (such as A-150 manufactured by Standard Imaging) simulates soft body tissue (muscle) and has been used for both ground-based as well as space-based (i.e., Space Station) experiments.

Table 5: Instrument design characteristics

Low LET detectors	9.6 cm^2 circular, 1000 microns thick
High LET detectors	9.6 cm^2 circular, 140 microns thick
TEP absorber 1	5.4 cm cylinder
TEP absorber 2	2.7 cm cylinder
Zenith FOV	35 degrees, 6-detector coincidence
Nadir FOV	75 degrees, for D3D4D5D6 coincidence
Geometry factor	0.1 cm^2 sr (D1D2 events)
LET range	0.2 - 7 MeV/micron (Si)
Incident particle energy range	≥20 MeV (H) ≥87 MeV/nucleon (Fe)

Solid-state detectors use semi-conducting crystals (in CRaTER's case, silicon) with n-type (electron-rich, electron conducting) and p-type (electron-deficient, hole conducting) regions.

When a reversed bias voltage is applied across the junction, the unbonded electrons in the semiconductor are pushed away from the voltage source, while the holes are pulled towards it. This leaves a neutral area void of charge and current at the junction of the sectors, called the depletion region. As incoming radiation (e.g., a solar proton or cosmic ray particle) collides with the depletion region, electron-hole pairs are formed in the material (where a once bonded electron is freed from its atom, leaving a hole). The electron and the hole respond to the applied voltage, and a small current is created. This current can be detected and later analyzed.

A cold environment greatly reduces the transmission of thermal signals. In addition, the solid state of the semi-conducting material makes it easier to detect those signals attributable to freed electrons.

Tissue equivalent plastic (or TEP) is a plastic recipe designed to simulate human tissue. It includes hydrogen and nitrogen percentages-by-composition that are similar to that found in human skin and muscle. Scientists can use the atomic-level effects that radiation has on the TEP to deduce what sort of similar effects may occur in humans.

2.2.1 Scientific objectives

The primary goal of CRaTER is to characterize the global lunar radiation environment and its biological impacts. This objective is critical if we are to implement a sustained, safe, and affordable human and robotic program to search for evidence of life, understand the history of the solar system, and prepare for future human exploration, a vision established by the Presidential Space Exploration Policy Directive in 2004.

In order to achieve this high-priority objective, the CRaTER investigation team established the following interrelated investigation goals:

- Measure and characterize that aspect of the deep space radiation environment, LET spectra of galactic and solar cosmic rays (particularly above 10 MeV), most critically important to the engineering and modeling communities to assure safe, long-term, human presence in space.
- Develop a novel instrument, steeped in flight heritage, that is simple, compact, and comparatively low-cost, but with a sufficiently large geometric factor needed to measure LET spectra and its time variation, globally, in the lunar orbit.
- Investigate the effects of shielding by measuring LET spectra behind different amounts and types of areal density, including tissue-equivalent plastic.
- Test models of radiation effects and shielding by verifying/validating model predictions of LET spectra with LRO measurements, using high-quality GCR and SPE spectra available contemporaneously on ongoing/planned NASA missions.

2.2.2 Radiation

Radiation has a potential effect on a wide variety of life. Beginning with the ionization of atoms and resulting in eventual cell damage, radiation may impact higher-level biological functions. The most critical damage is that which occurs in the DNA of cells.

At the molecular level, there are four possible effects that radiation may have on humans.

The first group of effects has no negative consequences for higher-level biological functions. Either cells remain undamaged by the radiation (in this case, the ionization of materials in the cell may produce chemical reactions which occur normally in the cell) or cells may be damaged, but not irreparably so. Often, even damage to chromosomes may occur with few long-term effects because the cell is able to detect and repair a limited amount of damage. Even without radiation dosage, changes and repairs in cells, including chromosomes, occur constantly in our bodies.

The second group of effects is more critical and will most likely have a negative impact on higher-level biological functions. Cells may be damaged and either begin operating abnormally or die. If enough damage is done and a cell is unable to completely repair itself, it may perform further functions abnormally, including reproduction. This usually occurs when cells are exposed to a lower dose of radiation over an extended period of time (or chronic radiation). It is this kind of exposure that may lead to cancer and genetic effects (problems in offspring), depending on the strength of the dose. With exposure to high-dose, short-term radiation (or acute radiation), damage may occur to the point where a cell is unable to perform any further function, including reproduction, and may even die. On a large enough scale (for example, at the organ level) this kind of damage is likely to cause radiation sickness. Symptoms of radiation sickness include skin that seems slightly sunburned, hair loss, fatigue, internal bleeding, fever, nausea, dehydration and diarrhea, bleeding ulcers, loss of coordination, confusion, coma, convulsions, shock, and more.

2.3 CRaTER Data Sets

The standard product types generated by the CRaTER SOC are listed in Table 6.

Table 6: Data Set Names and Contents

Standard Data Product ID	Key/Physical Parameters	NASA Level	COD MAC	Processing Inputs	Product Format

`CRAT_L0_PRI`
`CRAT_L0_SEC`
`CRAT_L0_HK`
	Raw CRaTER Experiment Data Record: pulse heights, secondary science, and instrument housekeeping	0	2	Raw data from LRO MOC as recorded on LRO	Binary CCSDS Packets

`CRAT_L1_PRI`
`CRAT_L1_SEC`
`CRAT_L1_HK`
	CRaTER Calibrated Data Record, split into primary and secondary science data, and housekeeping	1	3	Level 0 data with pulse heights in eV & housekeeping in engineering units	ASCII

`CRAT_L2_PRI`
`CRAT_L2_SEC`
`CRAT_L2_HK`
	CRaTER Derived Data Record, part 1: LET deposition in silicon. (Pulse heights converted into energy deposited within unit path length through each detector.)	2	3/4[1]	Level 1 data with pulse heights converted to LET energy and UTC time tags added; housekeeping in engineering units, conditioned.	ASCII

[1] The `CR_L2_HK` and `CR_L2_SEC` products are CODMAC Level 3, `CR_L2_PRI` is Level 4.

The Level 0 products, commonly referred to as the Experiment Data Record (EDR), consist of binary CCSDS packets, output by the instrument, stored in the spacecraft's solid-state recorder, and transmitted to the ground. The only changes made to these files by spacecraft and ground processing are as follows:

- Removal of duplicate data packets and sorting the remainder in ascending time order
- Sorting and merging of the data packets into files that contain a single packet type and span one 24 hour interval from 0h UTC
- Update of some file header fields to document the data content and time range

Each raw CRaTER data file output from the instrument (`MOC-4` and `MOC-5` in Table 7) is a time-ordered series of measurements, prefixed by a 64-byte header that is created onboard. EDR products are generated for all mission phases during which CRaTER data are acquired.

Level 1 data products differ from Level 0 in three important respects: they are written in fixed-length ASCII records, their detector values are converted to energy (in electron volts), and the housekeeping fields are converted to engineering units (i.e., volts, amps, degrees centigrade, etc.)

Level 2 data products are similar to Level 1 but differ in three respects: the detector values are also converted to lineal energy transfer (eV/µm), geometrical fields have been added to the secondary housekeeping, and the housekeeping fields have been "conditioned" to eliminate corrupted telemetry values and average over a suitable time window.

2.3.1 Input Data Files

Table 7 describes the files that are transmitted from the CRaTER instrument to the MOC, and The instrument products are described in detail in Section 4 of this document. The other products are defined in §4 of 431–ICD–000049 (see §2.6).

Table 7: Raw Data Products

ID	Product	Format	File Name
MOC-4	CRaTER Housekeeping Data	CCSDS	CRAT_*yyyyddd*_*nnnnnnn*.hk
MOC-5	CRaTER Raw Measurement Data	CCSDS	CRAT_*yyyyddd*_*nnnnnnn*.sci

Table 8 lists the additional files received from the LRO MOC and which will be included in the `EXTRAS` directory of the CRaTER EDR archive. One (`MOC—3`) comes from other spacecraft systems, and the remaining 13 come from the MOC itself.

Table 8: Ancillary Data Products

ID	Product	Format	File Name
MOC-2	SLCK Clock Correlation	SPICE	LRO_CLKCOR_*yyyyddd*_V*vv*.tsc
MOC-3	Spacecraft Housekeeping Data	CCSDS	CRAT_SCHK_*yyyyddd*_*nnnnnnn*.dat
MOC-7	Daily Command Load Report	ASCII	LROATS_*yyyyddd*_V*vv*.txt
MOC-33	Event Kernel	SPICE	LRO_EvtKer_*yyyyddd*_V*vv*.txt
MOC-40	Frame Kernels	SPICE	LRO_FRAMES_*yyyyddd*_V*vv*.txt
MOC-42	Definitive Spacecraft Orientation (CK)	SPICE	FDF35_*yyyyddd*_*yyyyddd*_*nnn*.dsp
MOC-46	CRaTER Housekeeping Summary	ASCII	CRAT_*yyyyddd*_*nnnnnnn*_hk.meta
MOC-47	CRaTER Raw Measurement Summary	ASCII	CRAT_*yyyyddd*_*nnnnnnn*_sci.meta
FDF-29	Definitive Spacecraft Ephemeris (SPK)	SPICE	FDF29_*yyyyddd*_*yyyyddd*_*nnn*.dsp
NAIF-1	Planetary Ephemeris (SPK)	SPICE	**TBD**
NAIF-2	Leap Second Kernel (LSK)	SPICE	**TBD**
NAIF-3	Generic Planetary Constants (PCK)	SPICE	**TBD**

2.4 Pipeline Processing

The products received from the MOC are staged at the CRaTER SOC until all of the necessary inputs are available that relate to a particular 24-hour period, starting and ending at 0h UTC. The Level 0, 1, and 2 products are then generated in a 4-step process, as follows:

1. SPICE kernels (see Table 8) and CRaTER calibration tables are read.
2. All CRaTER raw telemetry files (see Table 7) are read and, if their time fields fall within the desired 24-hour period (plus a few minutes either side), they are written to a set of 3 temporary files each containing a single packet type: primary science, secondary science, or instrument housekeeping. Garbled telemetry packets are reported.
3. The three temporary files are read, sorted into ascending time order, and rewritten. Duplicate packets are dropped after reporting any mis-matches.
4. The temporary files are read a second time, gaps are noted, and those packets that fall strictly within the 24-hour period are written out as Level 0 products. At the same time, the Level 1 and 2 product records are created from the corresponding Level 0 records. Level 1 housekeeping fields are produced from the raw Level 0 values and the calibration tables, as are Level 2 housekeeping fields, except that the latter are also "conditioned" by taking the time-average of several consecutive raw values after throwing away the largest and smallest values. The energy and LET fields in the Level 1 and 2 primary science records are created from the calibration tables and from the temperature fields in the temporary housekeeping files. The Level 1 secondary science records are merely the translation into ASCII of their Level 0 equivalents, but the Level 2 secondary science records also include geometrical information derived from the SPICE kernels.

Each 24-hour period therefore results in 9 data products (Level 0, 1, and 2, each of primary and secondary science and housekeeping), and 9 PDS detached label files. Three additional files are created, which will be reported in various directories of the CRaTER archive volumes:

- an *index* file containing the product file names and dates, which will be collected in the `INDEX.TAB` and `CUMINDEX.TAB` files in the `INDEX` directory;
- a *gap* file, which will be collected, according to packet type, in the `GAPS_PRI.TAB`, `GAPS_SEC.TAB`, and `GAPS_HK.TAB` files in the `DOCUMENT` directory of Level 0 products;
- and a *log* file reporting everything else, which will be found in the `DATA` subdirectories with the products to which it refers.

Consult §4 for more detailed information about these files and their locations within the archive.

At infrequent intervals, CRaTER will be operated in a *Calibration Mode*, in which the spacecraft will be rotated to point the instrument to the Moon's limb. The data collected during this procedure, combined with measurements from CRaTER's *pulser* mode, will be used to update the calibration coefficients used by the pipeline software to convert the raw Level 0 detector values to energy and LET. These calibration changes will be documented in `ERRATA.TXT`, in `MODE_CHANGES.TAB` in the `DOCUMENT` directory, and in the `NOTE` fields of the PDS label files describing the individual products.

2.5 Scope of this document

The specifications in this SIS apply to all CRaTER Standard Data Record products submitted for archive to the Planetary Data System (PDS), for all phases of the LRO mission. Some sections of this document describe parts of the CRaTER archive and archiving process that are managed by the PDS archive team. These sections have been provided for completeness of information and are not maintained by the CRaTER team.

2.6 Applicable Documents

ISO 9660-1988, Information Processing—Volume and File Structure of CD-ROM for Information Exchange, 04/15/1988.

Planetary Data System Proposer's Archiving Guide, Version 1.11, JPL D-26359, 01/03/2007.

Planetary Data System Standards Reference, Version 3.7, JPL D-7669, Part 2, 03/20/2006

Planetary Science Data Dictionary Document, Planetary Data System, JPL D-7116, Version 1r65, 02/2007.

Lunar Reconnaissance Orbiter Mission Concept of Operations, 431-OPS-000042, 08/12/2005.

Lunar Reconnaissance Orbiter Project Data Management and Archive Plan, 431-PLAN-00182.

Detailed Mission Requirements for the Lunar Reconnaissance Orbiter Ground System, 431-RQMT-000048, Rev. B, 09/19/2006.

Spacecraft to CRaTER Data Interface Control Document, 431-ICD-000104, Rev. B, 03/30/2007.

External Systems Interface Control Document for the Lunar Reconnaissance Orbiter Ground System, 431-ICD-000049, v1.0, 07/17/2006.

CRaTER Science Operations Center Requirements Document, 32-01209, Rev. A, 10/25/2006.

CRaTER Science Team and PDS–PPI Node ICD, 32-01280, Rev. A, 10/27/2006.

CRaTER Information Technology Security Plan, 32-01208, Rev. A, 07/01/2007.

CRaTER Functional Instrument Description and Performance Verification Plan, 32-05002, Rev. 01, 06/20/2006.

CRaTER Calibration Plan, 32–01207, Rev. A, 09/04/2007.

2.7 Audience

This document is intended to be useful to those who wish to understand the format and content of the CRaTER Standard Data Record submitted to the PDS archive. Such users might typically be software engineers, data analysts, or planetary scientists.

3 Archive volume generation

The CRaTER Standard Data Record archive collection is produced by the CRaTER Science Operations Team in cooperation with the PDS Planetary Plasma Interactions (PPI) Node at the University of California, Los Angeles (UCLA). The archive volume creation process described in this section sets out the roles and responsibilities of both these groups. The assignment of tasks has been agreed by both parties, and codified in an ICD (32–01280, see §2.6). Archived data received by the PPI Node from the CRaTER team will be made electronically available to PDS users as soon as practicable but no later than as laid out in Table 9.

3.1 Data transfer methods and delivery schedule

The CRaTER team will deliver data to the PPI Node in standard product packages containing three months of data, also adhering to the schedule set out in Table 9. Each package will comprise both data and ancillary data files, organized into directory structures consistent with the volume design described in Section 4, and combined into a deliverable file(s) using file archive and compression software. When these files are unpacked at the PPI Node in the appropriate location, the constituent files will be organized into the archive volume structure.

Table 9: Data delivery schedule

Date	Delivery
End of commissioning (nominally November 2008) + 6 months	Selected data from cruise and from the lunar-orbit commissioning period; the first 3 months of post-commissioning data
Every 3 months	Next 3 months of prime-mission data

The archives will be sent electronically from the CRaTER SOC to a user account on the PPI node using the *ssh* protocol. The SOC operator will copy each volume (see Table 11) in the form of a compressed *tar* archive (a.k.a. *tarball*) to an appropriate location within the PPI file system, and will notify the PPI node via e-mail. Only those files that have changed since the last delivery will be included. The PPI operator will decompress the data, using the *tar* checksums and the `EXTRAS/MANIFEST.TXT` and `EXTRAS/CHECKSUM.TXT` files to verify that the archive is complete. Once this has been checked, the PPI operator will send a confirmatory e-mail to the CRaTER team to mark the delivery as “received”.

Following receipt of a data delivery, PPI will organize the data into PDS archive volume structure within its online data system. PPI will generate all of the required files associated with a PDS archive volume (index file, read-me files, etc.) as part of its routine processing of incoming CRaTER data. Newly delivered data will be made available publicly through the PPI online system once accompanying labels and other documentation have been validated. It is anticipated that this validation process will require at least fourteen working days from receipt of the data by PPI. The first two data deliveries are expected to require somewhat more time for the PPI Node to process before making the data publicly available.

The LRO prime mission begins at Lunar Orbit Insertion (LOI), nominally October/November 2008, and lasts for 13 months. Table 9 formalizes the data delivery schedule for all of the CRaTER cruise and prime mission data. Data delivery from SOC to PPI node will occur on the 15th of the month and the data will be publicly available on the 1st of the following month. Archiving of products from any extended mission period will be negotiated with the LRO Project at a later date.

3.2 Data validation

The CRaTER standard data archive volume set will include all CRaTER data acquired during the LRO mission. The archive validation procedure described in this section applies to volumes generated during both the cruise and prime phases of the mission.

PPI node staff will carefully examine the first archive volume that they receive that contains data from the nominal LRO mission to determine whether the archive is appropriate to meet the stated science objectives of the instrument. The PPI node will also review the archive product generation process for robustness and ability to detect discrepancies in the end products; documentation will be reviewed for quality and completeness.

As expertise with the instrument and data develops the CRaTER team may decide that changes to the structure or content of its standard data products are warranted. Should these changes be implemented, the new data product and archive volume will be subjected to a full PDS peer review, and this document will be revised to reflect the modified archive. Table 2 lists the history of all modifications to the archive structure and contents.

Additionally, the CRaTER team may generate and archive special data products that cover specific observations or data-taking activities. This document does not specify how, when, or under what schedule, any such special archive products are generated.

3.3 Data product and archive volume size estimates

CRaTER standard data products are organized into files that span a single Earth day of data acquisition, breaking at 0h UTC. Files vary in size depending on the telemetry rate and allocation. Table 10 summarizes the expected sizes of the CRaTER standard products, assuming an average event rate of 60 per second.

All CRaTER standard data are organized by the PDS team onto a single archive volume covering a time interval governed by the physical capacity of the archive volume media. The data on the volume are organized into one-day subdirectories.

Table 10: Data product size and archive volume production rate

Data Product	Production rate (approximate)	Size for 1-year primary mission
Level 0 Science & Housekeeping	52 MB per day	19 Gbytes
Level 1 Science & Housekeeping	625 MB per day	228 Gbytes
Level 2 Science & Housekeeping	1484 MB per day	541 Gbytes
CRaTER Total	2.0 Gbytes per day	789 GBytes

Following receipt of CRaTER data by the PPI Node it is expected that fourteen working days will be required before the data are made available on PPI web pages. Once sufficient data have accumulated a new archive volume will be created by PPI. It is anticipated that two weeks will be required to produce and validate this new archive volume once the data delivery that fills the volume has been made available online.

3.4 Backups and duplicates

The PPI Node keeps three copies of each archive volume. One copy is the primary archive volume, another is an onsite backup copy, and the final copy is a local, off-site backup copy. The volumes sent to the CRaTER team and the PDS Engineering Node are to be kept by those institutions. Once the archive volumes are fully validated and approved for inclusion in the archive, a copy of the data is sent to the National Space Science Data Center (NSSDC) for long-term archive in a NASA-approved deep-storage facility. The PPI Node may maintain additional copies of the archive volumes, either on or off-site as deemed necessary.

Figure 1 illustrates the process of duplicating and disseminating the CRaTER standard archive volumes.

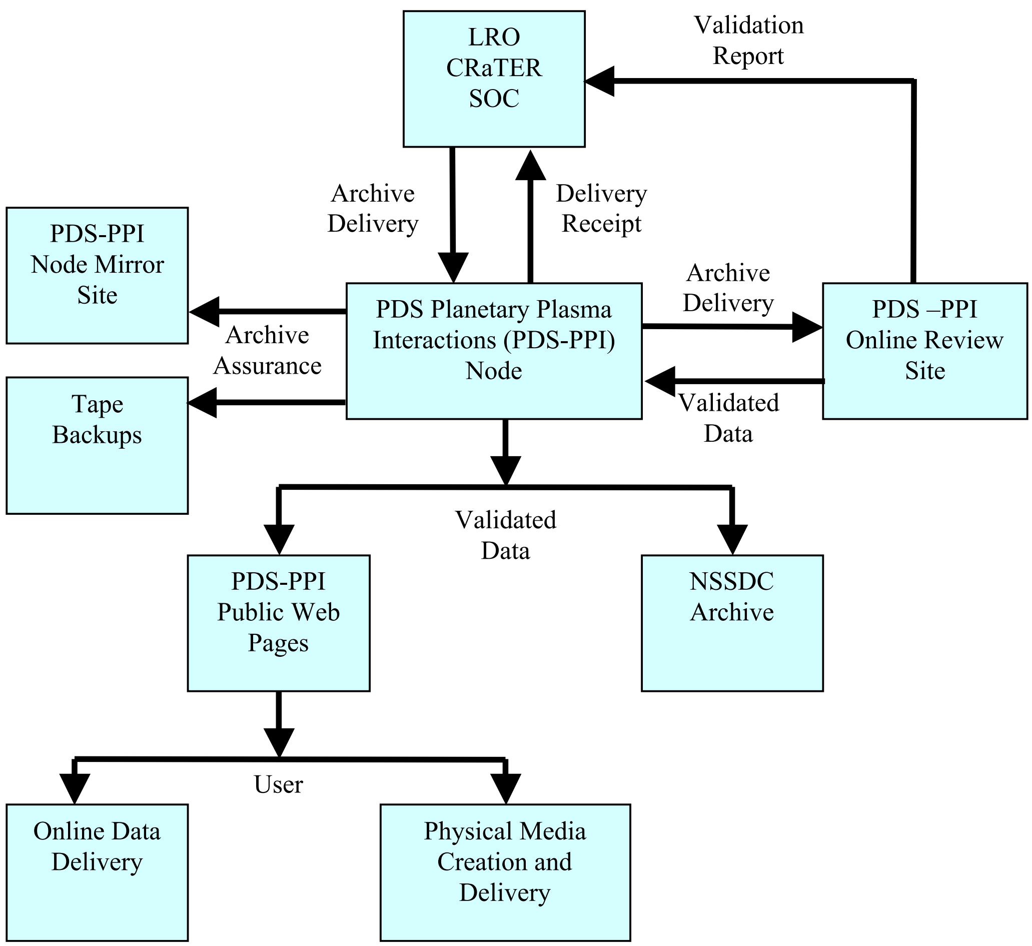

Figure 1: Duplication and dissemination of CRaTER standard archive volumes

3.5 Labeling and identification

Each CRaTER data volume bears a unique volume ID using the last two components of the volume set ID [*PDS Standards Reference*, see §2.6]. For each physical medium, the volume IDs are `USA_NASA_PDS_LROCRA_`*nnnn*, where `LROCRA` is the `VOLUME_SET_ID` defined by the PDS and *nnnn* is the sequence number of the individual volume. Hence the first CRaTER Level 0 volume has the volume ID `LROCRA_0001`, as shown in Table 11.

Table 11: PDS Data Set Name Assignments

Level	DATA_SET_ID	VOLUME_ID
CRaTER EDR	LRO-L-CRAT-2-EDR-RAWDATA-V1.0	LROCRA_0001
CRaTER CDR	LRO-L-CRAT-3-CDR-CALIBRATED-V1.0	LROCRA_1001
CRaTER DDR–1	LRO-L-CRAT-3/4-DDR-PROCESSED-V1.0	LROCRA_2001
CRaTER DDR–2	LRO-L-CRAT-5-DDR-ACCUMULATED-V1.0	LROCRA_3001
CRaTER DAP	LRO-L-CRAT-5-DAP-MODELLED-V1.0	LROCRA_4001

4 Archive volume contents

This section describes the contents of the CRaTER standard product archive collection volumes, including the file names, file contents, file types, and the organizations responsible for providing the files. The complete directory structure is shown in Figure 2. All the ancillary files described herein appear on each CRaTER standard product volume, except where noted.

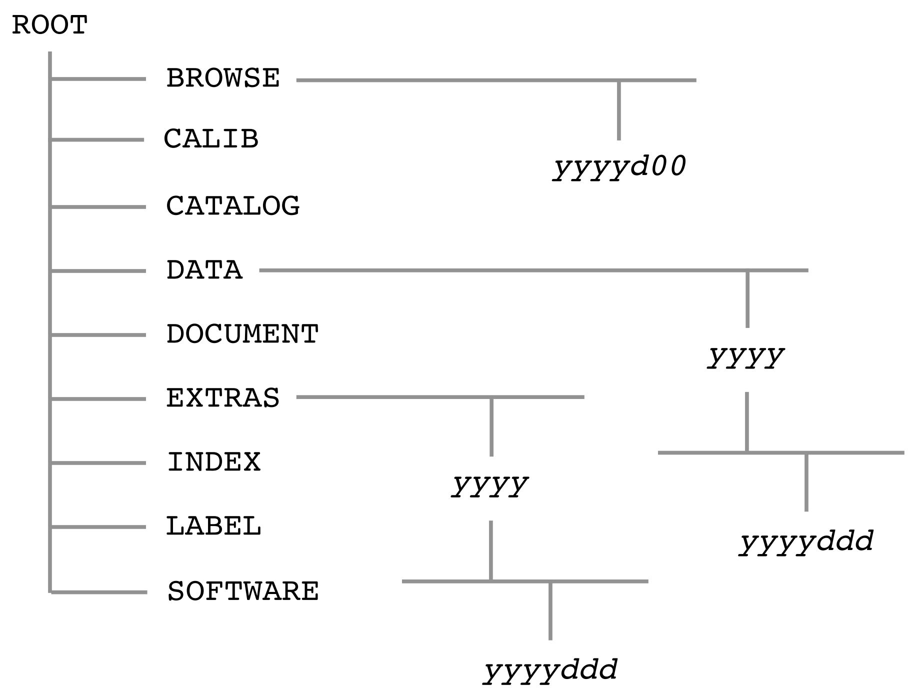

Figure 2: Archive volume directory structure

4.1 Root directory

The files listed in Table 12 are contained in the (top-level) root directory, and are produced by the CRaTER team in consultation with the PPI node of the PDS. With the exception of the hypertext file and its label, all of these files are required by the PDS volume organization standards.

Table 12: Root directory contents

File	Description	Responsibility
AAREADME.HTM	HTML version of AAREADME.TXT	CRaTER team
AAREADME.LBL	A PDS detached label that describes AAREADME.HTM	CRaTER team
AAREADME.TXT	This file completely describes the volume organization and contents (PDS label attached)	CRaTER team
ERRATA.TXT	A text file containing a cumulative listing of comments and updates concerning all CRaTER standard products on all CRaTER volumes in the volume set published to date	CRaTER team
VOLDESC.CAT	A description of the contents of this volume in a PDS format readable by both humans and computers	CRaTER team

4.2 BROWSE directory

The BROWSE directory contains daily browse plots of the CRaTER data, split into 100-day intervals. The contents of this directory and its subdirectories are described in Table 13.

Table 13: BROWSE directory contents

File	Description	Responsibility
BROINFO.TXT	A description of the contents of this directory	CRaTER team
*yyyyd*00	Subdirectories, each spanning a 100-day interval from *yyyyd*00 through *yyyyd*99	CRaTER team
*yyyyd*00/*yyyyddd*.PDF	A PDF file containing a plot of the events acquired on day *ddd* of year *yyyy*	CRaTER team
*yyyyd*00/*yyyyddd*.LBL	The PDS label describing the corresponding plot file	CRaTER team

4.3 CALIB directory

The CALIB directory, which only exists on the Level 1 and 2 archives, contains a copy of the calibration plan and the ancillary data used to calibrate the CRaTER instrument performance. The contents of this directory are described in Table 14.

Table 14: CALIB directory contents

File	Description	Responsibility
CALINFO.TXT	A description of the contents of this directory	CRaTER team
CRAT_CAL_PLAN.HTM	The CRaTER Calibration Plan (HTML format)	CRaTER team
CRAT_CAL_PLAN.LBL	PDS label describing CRAT_CAL_PLAN.PDF	CRaTER team
CRAT_CAL_PLAN.PDF	The CRaTER Calibration Plan (Acrobat™ format)	CRaTER team
*.DAT	Calibration data files in Level 0 format	CRaTER team
*.LBL	PDS label describing the corresponding DAT file	CRaTER team

4.4 CATALOG directory

The files in the CATALOG directory provide a top-level understanding of the LRO mission, spacecraft, instruments, and data sets in the form of completed PDS templates. The information necessary to create the files is provided by the CRaTER team and formatted into standard template formats by the PPI Node. The files in this directory are coordinated with PDS data engineers at both the PPI Node and the PDS Engineering Node.

Table 15: CATALOG directory contents

File	Description	Responsibility
CATINFO.TXT	A description of the contents of this directory	CRaTER team
CRAT_INST.CAT	PDS instrument catalog description of the CRaTER instrument	CRaTER team
CRAT_L0_DS.CAT	PDS data set catalog description of the CRaTER Level 0 (raw) data files	CRaTER team, PPI Node

File	Description	Responsibility
CRAT_L1_DS.CAT	PDS data set catalog description of the CRaTER Level 1 data files	CRaTER team, PPI Node
CRAT_L2_DS.CAT	PDS data set catalog description of the CRaTER Level 2 data files	CRaTER team, PPI Node
CRAT_REF.CAT	CRaTER-related references mentioned in other CAT files	CRaTER team
INSTHOST.CAT	A description of the LRO spacecraft	LRO Project
MISSION.CAT	PDS mission catalog description of the LRO mission	LRO Project
PERSON.CAT	PDS personnel catalog description of CRaTER team members and other persons involved with generation of CRaTER standard data products	CRaTER team
PROJ_REF.CAT	References mentioned in INSTHOST.CAT and MISSION.CAT	LRO Project
CATINFO.TXT	A description of the contents of this directory	CRaTER team
CRAT_INST.CAT	PDS instrument catalog description of the CRaTER instrument	CRaTER team
CRAT_L0_DS.CAT	PDS data set catalog description of the CRaTER Level 0 (raw) data files	CRaTER team, PPI Node
CRAT_L1_DS.CAT	PDS data set catalog description of the CRaTER Level 1 data files	CRaTER team, PPI Node
CRAT_L2_DS.CAT	PDS data set catalog description of the CRaTER Level 2 data files	CRaTER team, PPI Node
CRAT_REF.CAT	CRaTER-related references mentioned in other CAT files	CRaTER team

4.5 DATA directory

4.5.1 Contents

The DATA directory contains the data files produced by the CRaTER team. In the Level 0 archive, these files contain the raw binary instrument data in the form of CCSDS telemetry packets, organized into correct time sequence, time tagged, and edited to remove obviously bad data. In the Level 1 and Level 2 archives, the contents of the DATA directory are ASCII file that result from passing the corresponding Level 0 files through the processing pipeline.

The data files are of the highest quality possible. Any residual issues are documented in AAREADME.TXT and ERRATA.TXT. Users are referred to these files for a detailed description of any outstanding matters associated with the archived data.

Additional files relevant to the data files are located in the EXTRAS directory (see §4.7). These include ancillary information files (engineering, housekeeping) and channelized data files (e.g. spacecraft attitude, status information for CRaTER instrumental subsystems), provided to facilitate data processing and analysis.

Table 16: DATA directory contents

File	Description	Responsibility
`DATAINFO.TXT`	A description of the contents of this directory	CRaTER team
`yyyy`	Subdirectories containing CRaTER data acquired in year *`yyyy`*.	CRaTER team

4.5.2 Subdirectory structure

In order to manage files in an archive volume more efficiently the `DATA` directory is divided into subdirectories. The two levels of division are based on time; data are organized into yearly subdirectories, which are further divided into a number of daily sub-subdirectories. The naming convention for the yearly directories is *`yyyy`*, and for the daily directories it is *`yyyyddd`*, where *`ddd`* is the three-digit day of year. For example, all data for the year 2009 are contained below the directory `2009`, with data for Jan 1 2009 UTC found in the subdirectory `2009/2009001`, and so on.

4.5.3 Required files

A PDS label describes each file in the `DATA` path of an archive volume. Text documentation files have attached (internal) PDS labels and data files have detached labels. Detached PDS label files have the same root name as the file they describe but have the extension `LBL`. The format of the data files for each standard data product is constant throughout the archive volume and is described in `FMT` files located in the `LABEL` directory (see §4.9).

4.5.4 The *`yyyy/yyyyddd`* subdirectory

This directory contains CRaTER data files and their corresponding PDS labels. As shown in Table 17, the data in these files span a time interval of one day, the particular day being identified from both the file name and the name of the parent directory. The names also contain a 2-digit version. The initial version is `V01`.

Table 17: DATA/yyyy/yyyyddd directory contents

Filename	Description
CRAT_*yyyyddd*_V*nn*.LOG.TXT	Pipeline log file (ASCII)
CRAT_L0_HK_*yyyyddd*_V*nn*.DAT	CRaTER Level 0 Housekeeping Data
CRAT_L1_HK_*yyyyddd*_V*nn*.TAB	CRaTER Level 1 Housekeeping Data
CRAT_L2_HK_*yyyyddd*_V*nn*.TAB	CRaTER Level 2 Housekeeping Data
CRAT_L*n*_HK_*yyyyddd*_V*nn*.LBL	CRaTER Level *n* Housekeeping Data PDS Label
CRAT_L0_PRI_*yyyyddd*_V*nn*.DAT	CRaTER Level 0 Primary Science Data
CRAT_L1_PRI_*yyyyddd*_V*nn*.TAB	CRaTER Level 1 Primary Science Data
CRAT_L2_PRI_*yyyyddd*_V*nn*.TAB	CRaTER Level 2 Primary Science Data
CRAT_L*n*_PRI_*yyyyddd*_V*nn*.LBL	CRaTER Level *n* Primary Science Data PDS Label
CRAT_L0_SEC_*yyyyddd*_V*nn*.DAT	CRaTER Level 0 Secondary Science Data
CRAT_L1_SEC_*yyyyddd*_V*nn*.TAB	CRaTER Level 1 Secondary Science Data
CRAT_L2_SEC_*yyyyddd*_V*nn*.TAB	CRaTER Level 2 Secondary Science Data
CRAT_L*n*_SEC_*yyyyddd*_V*nn*.LBL	CRaTER Level *n* Secondary Science Data PDS Label

Level 0 data file names end in DAT, indicating their binary contents, while the Level 1 and 2 data files, which contain fixed-length ASCII records, end in TAB. Each file is accompanied by a PDS label (LBL) describing its contents, and contain pointers to the relevant format definition files (FMT) in the LABEL directory. The labels permit the contents of most of the products to be browsed by PDS software, e.g., *NASAView*, *tbtool*, etc. The exception is the Level 0 Primary Science product, since it contains varying-length records that do not comply with PDS standards. This product can instead be listed by programs in the SOFTWARE directory (see §4.10).

4.6 DOCUMENT directory

The DOCUMENT directory contains a range of documentation considered either necessary or useful for users to understand the archive data set. Documents may be included in multiple forms, for example, ASCII, PDF, MS Word, or HTML. PDS standards require that any documentation needed for use of the data be available in an ASCII format. HTML is an acceptable ASCII format in addition to plain text. The following files are contained in the DOCUMENT directory, grouped into the subdirectories shown.

Table 18: DOCUMENT directory contents

Filename	Description	Responsibility
DOCINFO.TXT	A description of the contents of this directory	CRaTER team
GAPS_HK.LBL	A PDS detached label for GAPS_HK.TXT	CRaTER team PPI Node
GAPS_HK.TAB	A cumulative listing of the missing Housekeeping packets up to and including the days for the current volume	CRaTER team
GAPS_PRI.LBL	A PDS detached label for GAPS_PRI.TXT	CRaTER team
GAPS_PRI.TAB	A cumulative listing of the missing Primary Science packets for the days up to and including the days for the current volume	CRaTER team
GAPS_SEC.LBL	A PDS detached label for GAPS_SEC.TXT	CRaTER team
GAPS_SEC.TAB	A cumulative listing of the missing Secondary Science packets for the days up to and including the days for the current volume	CRaTER team
MODE_CHANGES.LBL	A PDS detached label for MODE_CHANGES.TAB	CRaTER team
MODE_CHANGES.TAB	A cumulative listing of instrument mode changes since launch	CRaTER team
VOLSIS*.JPG	Graphics files used by VOLSIS.HTM	CRaTER team
VOLSIS.HTM	The SIS in HTML format	CRaTER team
VOLSIS.LBL	A PDS detached label for the SIS document	CRaTER team
VOLSIS.PDF	The SIS in PDF format	CRaTER team

4.7 EXTRAS directory

The `EXTRAS` directory contains files which facilitate the use of the archive volume but which are not considered part of the archive itself. At the top level (see Table 19) are the checksum and manifest files that describe the contents of the entire archive volume. The directory is divided into subdirectories in the same manner as the `DATA` directory. The two levels of division are based on time; data are organized into yearly subdirectories, which are further divided into a number of daily sub-subdirectories. The naming convention for the yearly directories is *yyyy*, and for the daily directories it is *yyyyddd*, where *ddd* is the three-digit day of year. For example, all data for the year 2009 are contained below the directory `2009`, with data for Jan 1 2009 UTC found in the subdirectory `2009/2009001`, and so on.

Included in the subdirectories (see Table 20) are those SPICE kernels that were used to process the data files. The file names are as received from the LRO MOC and may not therefore obey PDS conventions. To reprocess the CRaTER data, users are advised to check with the PDS NAIF Node for the latest versions of the kernel files.

Besides the subdirectories, the `EXTRAS` directory may also contain additional files that were not anticipated when the archive structure was defined. These files will be described in `INDXINFO.TXT` and in the `ERRATA.TXT` file in the root directory of the archive.

Table 19: EXTRAS subdirectory contents

Filename	Description
`INDXINFO.TXT`	A description of the contents of this directory
`CHECKSUM.LBL`	A PDS detached label that describes `CHECKSUM.TXT`
`CHECKSUM.TXT`	A file containing a list of all files on the current volume, along with their MD5 checksums
`MANIFEST.LBL`	A PDS detached label that describes `MANIFEST.TXT`
`MANIFEST.TXT`	A file containing a list of all files on the current volume
yyyy	Directories containing files relevant to year *yyyy*.

Table 20: EXTRAS/yyyy/yyyyddd subdirectory contents

Filename	Description
LRO_CLKCOR_*yyyyddd*_Vvv.tsc	SLCK Clock Correlation
CRAT_SCHK_*yyyyddd*_*nnnnnnn*.dat	Spacecraft Housekeeping Data
LROATS_*yyyyddd*_Vvv.txt	Daily Command Load Report
LRO_EvtKer_*yyyyddd*_Vvv.te	Event Kernel
LRO_FRAMES_*yyyyddd*_Vvv.tf	Frame Kernels
FDF35_*yyyyddd*_*yyyyddd*_nnn.bc	Definitive Spacecraft Orientation (CK)
CRAT_*yyyyddd*_*nnnnnnn*_hk.txt	CRaTER Housekeeping Summary
CRAT_*yyyyddd*_*nnnnnnn*_sci.txt	CRaTER Raw Measurement Summary
FDF29_*yyyyddd*_*yyyyddd*_nnn.bsp	Definitive Spacecraft Ephemeris (SPK)
TBD	Planetary Ephemeris (SPK)
TBD	Leap Second Kernel (LSK)
TBD	Generic Planetary Constants (PCK)

4.8 INDEX directory

The INDEX.TAB file contains a listing of all data products on the archive volume. The index (INDEX.TAB) and index information (INDXINFO.TXT) files are required by the PDS volume standards. The format of these ASCII files is described in §5.2.5. An online and web-accessible index file will be available at the PPI Node while data volumes are being produced.

Table 21: INDEX directory contents

File	Description	Responsibility
INDXINFO.TXT	A description of the contents of this directory	CRaTER team
INDEX.LBL	A PDS detached label that describes INDEX.TAB	CRaTER team
INDEX.TAB	A table listing all CRaTER data products on this volume	CRaTER team

4.9 LABEL directory

The LABEL directory contains format files (*.FMT) that describe the contents of the CRaTER files in the DATA subdirectories. They are themselves described by a LABINFO.TXT file.

Table 22: LABEL directory contents

File	Description	Responsibility
CRAT_L0_HDR.FMT	Bit-level description of Level 0 packet headers	CRaTER team
CRAT_L0_HK.FMT	Bit-level description of Level 0 housekeeping records	CRaTER team
CRAT_L0_PRI.FMT	Bit-level description of Level 0 primary science records	CRaTER team
CRAT_L0_SEC.FMT	Bit-level description of Level 0 secondary science records	CRaTER team
CRAT_L1_HK.FMT	Byte-level description of Level 1 housekeeping records	CRaTER team
CRAT_L1_PRI.FMT	Byte-level description of Level 1 primary science records	CRaTER team
CRAT_L1_SEC.FMT	Byte-level description of Level 1 secondary science records	CRaTER team
CRAT_L2_HK.FMT	Byte-level description of Level 2 housekeeping records	CRaTER team
CRAT_L2_PRI.FMT	Byte-level description of Level 2 primary science records	CRaTER team
CRAT_L2_SEC.FMT	Byte-level description of Level 2 secondary science records	CRaTER team
LABINFO.TXT	A description of the contents of this directory	CRaTER team
LROHDR.FMT	Bit-level description of 64-byte Level 0 file headers	CRaTER team

These files are used by several PDS software tools, e.g., *NASAView, tbtool*, etc., to browse the data products through their PDS labels. This is not true, however, for the Level 0 Primary Science product, since it contains varying-length records that cannot be defined by the PDS Object Definition Language used by the FMT files. The CRAT_L0_PRI.FMT file therefore contains a description of a maximum-length record (12-byte header followed by 432-byte data array), which may be useful to some future software development. Meanwhile, PERL and C++ code that can access all CRaTER products are located in the SOFTWARE directory (see CRATLIST.CPP and CRATLIST.PL).

4.10 SOFTWARE directory

The `SOFTWARE` directory (see Table 23) contains software used to display CRaTER Level 0 data. Since this software was developed exclusively at MIT and BU, and relates only to the manipulation of scientific data, it is in the public domain and exempt from export regulations.

Table 23: SOFTWARE directory contents

File	Description	Responsibility
`SOFTINFO.TXT`	A description of the contents of this directory	CRaTER team
`CRATLIST.CPP`	C++ source code that, when compiled and linked with the CRaTER object library, lists the contents of CRaTER Level 0 data files	CRaTER team
`CRATLIST.DAT`	Calibration data used by `CRATLIST.PL`	CRaTER team
`CRATLIST.PL`	PERL program to list the contents of CRaTER Level 0 data files	CRaTER team
`CRATER_LIB.CPP`	C++ functions to support the CRaTER object library	CRaTER team
`CRATER_LIB.H`	C++ header file defining the CRaTER object library	CRaTER team
`CRATER_LIB.HTM`	Description of CRATER_LIB routines in HTML format	CRaTER team
`CRATER_LIB.LBL`	PDS label file describing `CRATER_LIB.PDF`	CRaTER team
`CRATER_LIB.MAN`	Description of CRATER_LIB routines in *roff* format	CRaTER team
`CRATER_LIB.PDF`	Manual describing the CRaTER object library	CRaTER team
`CRATER_L0_LIB.CPP`	C++ object library to read CRaTER Level 0 files	CRaTER team
`CRATER_L0_LIB.H`	C++ header file defining CRaTER Level 0 record formats and input classes	CRaTER team
`CRATER_L0_LIB.HTM`	Description of CRATER_L0_LIB (HTML format)	CRaTER team
`CRATER_L0_LIB.MAN`	Description of CRATER_L0_LIB (*roff* format)	CRaTER team
`CRATER_L0_OUT.CPP`	C++ object library to write CRaTER Level 0 files	CRaTER team
`CRATER_L0_OUT.H`	C++ header file defining CRaTER Level 0 output classes	CRaTER team
`CRATER_L0_OUT.HTM`	Description of CRATER_L0_OUT (HTML format)	CRaTER team
`CRATER_L0_OUT.MAN`	Description of CRATER_L0_OUT (*roff* format)	CRaTER team
`CRATER_I1_LIB.CPP`	C++ object library to manipulate CRaTER Level 1 files	CRaTER team
`CRATER_L1_LIB.H`	C++ header file defining CRaTER Level 1 record formats and classes	CRaTER team
`CRATER_L1_LIB.HTM`	Description of CRATER_L1_LIB (HTML format)	CRaTER team
`CRATER_L1_LIB.MAN`	Description of CRATER_L1_LIB (*roff* format)	CRaTER team
`CRATER_L2_LIB.CPP`	C++ object library to manipulate CRaTER Level 2 files	CRaTER team
`CRATER_L2_LIB.H`	C++ header file defining CRaTER Level 2 record formats and classes	CRaTER team
`CRATER_L2_LIB.HTM`	Description of CRATER_L2_LIB (HTML format)	CRaTER team
`CRATER_L2_LIB.MAN`	Description of CRATER_L2_LIB (*roff* format)	CRaTER team

5 Archive volume format

This section describes the format of CRaTER standard archive volumes. Data that comprise the CRaTER standard product archives will be formatted in accordance with PDS specifications [see *Planetary Science Data Dictionary*, *PDS Archiving Guide*, and *PDS Standards Reference* in §2.6].

5.1 Volume format

Although the CRaTER team does not control the volume format to be used by the PDS, it is necessary to define the format in which the data sets are to be transmitted via network from the SOC to the PPI node. This will be in the form of compressed *tar* archives, as created by the open source *gtar* program. Pathnames, in lower-case letters only, will be relative to the ROOT directory, e.g., *"./data", "./index"*, etc.

5.2 File formats

The following section describes file formats for the kinds of files contained on archive volumes. For more information, see the *PDS Archive Preparation Guide* [see §2.6].

5.2.1 Document files

Document files with a `TXT` extension exist in nearly all directories. They are ASCII files with embedded PDS labels. All ASCII document files contain 80-byte fixed-length records, with a carriage return character (ASCII 13) in the 79th byte and a line feed character (ASCII 10) in the 80th byte. This format allows the files to be read by many operating systems, *e.g*., UNIX, MacOSX, Windows, etc.

In general, documents are provided in ASCII text format. However, some documents in the `DOCUMENT` directory contain formatting and figures that cannot be rendered as ASCII text. Hence these documents are also given in additional formats such as hypertext, Microsoft Word, and Adobe Acrobat (PDF). Hypertext files contains ASCII text plus hypertext mark-up language (HTML) commands that enable them to be viewed in a web browser such as *mozilla* or MS Internet Explorer. Hypertext documents may reference ancillary files, such as images, that are incorporated into the document by the web browser.

5.2.2 Tabular files

Tabular files (`TAB` extension) exist in the `DATA` and `INDEX` directories. Tabular files are ASCII files formatted for direct reading into database management systems on various computers. Columns are fixed length, separated by commas or white space, and character fields are enclosed in double quotation marks ("). Character fields are padded with spaces to keep quotation marks in the same columns of successive records. Character fields are left justified, and numeric fields are right justified. The "start byte" and "bytes" values listed in the labels do not include the commas between fields or the quotation marks surrounding character fields. The records are of fixed length, and the last two bytes of each record contain the ASCII carriage return and line feed characters. This line format allows a table to be treated as a fixed length record file on computers that support this file type and as a text file with embedded line delimiters on those that don't support it.

Detached PDS label files will describe all tabular files. A detached label file has the same name as the data file it describes, but with the extension `LBL`. For example, the file `INDEX.TAB` is accompanied by the detached label file `INDEX.LBL` in the same directory.

5.2.3 PDS labels

All data files in the CRaTER Standard Product Archive Collection have associated detached PDS labels [see the *Planetary Science Data Dictionary* and the *PDS Standards Reference* in §2.6]. These label files are named using the same prefix as the data file together with an `LBL` extension.

A PDS label, whether embedded or detached from its associated file, provides descriptive information about the associated file. The PDS label is an object-oriented structure consisting of sets of "`keyword = value`" declarations. The object that the label refers to (*e.g.* `IMAGE`, `TABLE`, etc.) is denoted by a statement of the form:

```
^object = location
```

in which the carat character (^, also called a pointer in this context) indicates where to find the object. In a PDS label, the location denotes the name of the file containing the object, along with the starting record or byte number, if there is more than one object in the file. For example:

```
^HEADER = ("98118.TAB", 1)
^TABLE = ("98118.TAB", 1025 <BYTES>)
```

indicates that the `HEADER` object begins at record 1 and that the `TABLE` object begins at byte 1025 of the file `98118.TAB`. The file `98118.TAB` must be located in the same directory as the detached label file.

Below is a list of the possible formats for the `^object` definition in labels in this product.

```
^object     = n
^object     = n <BYTES>
^object     = "filename.ext"
^object     = ("filename.ext", n)
^object     = ("filename.ext", n <BYTES>)
```

where

- *n* is the starting record or byte number of the object, counting from the beginning of the file (record 1, byte 1),
- `<BYTES>` indicates that the number given is in units of bytes (the default is records),
- *`filename`* is the up-to-27-character, alphanumeric upper-case file name,
- *`ext`* is the up-to-3-character upper-case file extension,
- and all detached labels contain ASCII records that terminate with a carriage return followed by a line feed (13_{10}, 10_{10}). This allows the files to be read by most computer operating systems, e.g., UNIX, MacOS, MSWindows, etc.

Examples of PDS labels required for the CRaTER archive are shown in Appendix B.

5.2.4 Catalog files

Catalog files (extension `CAT`) exist in the `Root` and `CATALOG` directories. They are plain text files formatted in an object-oriented structure consisting of sets of `"keyword = value"` declarations.

5.2.5 Index files

The PDS team provides PDS index files. The format of these files is described in this SIS document for completeness.

A PDS index table contains a listing of all data products on an archive volume. When a data product is described by a detached PDS label, the index file points to the label file, which in turn points to the data file. When a data product is described by an attached PDS label, the index file points directly to the data product. A PDS index is an ASCII table composed of required columns and optional columns (user defined). When values are constant across an entire volume, it is permissible to promote the value out of the table and into the PDS label for the index table.

To facilitate users' searches of the CRaTER data submission, a few optional columns will be included in the index table. In particular, the file start and stop times will be included. Table 24 contains a description of the CRaTER archive volume index files. Index files are by definition fixed length ASCII files containing comma-delimited fields. Character strings are quoted using double quotes, and left justified in their field, followed where necessary by trailing blanks. The "Start Byte" column gives the location of the first byte (counting from 1) of the column within the file, skipping over delimiters and quotation marks.

Table 24: Format of index files

Column Name	Start Byte	Bytes	Description
`FILE_NAME`	2	31	Name of product file within a `DATA/yyyyddd` directory.
`PATH_NAME`	36	50	The full specification of file name and the path to the PDS label file that describes the product, relative to the root of the archive volume.
`START_TIME`	88	23	Time (UTC) of the first record in the data file.
`STOP_TIME`	112	23	Time (UTC) of the last record in the data file.
`STANDARD_DATA_PRODUCT_ID`	137	12	The "type" of the data file. (see Table 6)
`DATA_SET_ID`	152	40	The PDS ID of the data set of which this file is a member. (see Table 11)
`PRODUCT_CREATION_DATE`	195	8	Date when the product was delivered to PDS.

5.2.6 Level 0 data files

As described in Section 2.3.1, the raw instrument data consist of three data packet types, recorded onboard in two files: one containing primary science packets, the other containing secondary science and housekeeping packets. During ground processing, these files are sorted into three sets of Level 0 files, one for each packet type. Each file begins with a 64-byte header, described in Table 25, followed by one or more data records as described in Table 26 to Table 28. Each record begins with a 12-byte header described in Table 29. All fields are to be interpreted as unsigned integers with their most significant bits recorded in the lowest byte offset, except *FileName*, which is a null-terminated array of ASCII characters.

Table 25: Format of Level 0 binary file header records

Byte	Bit	Length (bits)	Name	Description
0	0	32	*FileID*	Numerical file identifier (200=Primary Science, 201=Housekeeping, 202=Secondary Science)
4	32	32	*Spare*	Spare
8	64	32	*StartTimeSec*	S/C time (seconds from Jan 1 2001 UTC) of the first data record
12	96	32	*StartTimeSubSec*	S/C fractional time (LSB = 2^{-32} sec) of the first record
16	128	32	*StopTimeSec*	S/C time (seconds from Jan 1 2001 UTC) of the last data record
20	160	32	*StopTimeSubSec*	S/C fractional time (LSB = 2^{-32} sec) of the last record
24	192	320	*FileName*	Product file name, right-padded with NULs, *e.g.,* "`CRAT_L0_PRI_`*`yyyyyyy`*`_v`*`nn`*`.DAT`"

Table 26: Format of Level 0 primary science data file records

Byte	Bit	Length (bits)	Name	Description
0	0	96	*Header*	Primary & Secondary Headers, ApId=120 (see Table 29)
12	96	*n**6*12	*Event*[*n*][6]	Signals recorded in detectors 1 to 6 as a result of *n* single-particle events ($0 \leq n \leq 48$). These records are of varying length, which is recorded in the *PacketLength* field of the *Header* structure described in Table 29

Table 27: Format of Level 0 secondary science data file records

Byte	Bit	Length (bits)	Name	Description
0	0	96	*Header*	Primary & Secondary Headers, ApId=121 (see Table 29)
12	96	1	*BiasCntrl*	Detector Bias Delayed Control (1=enabled)
12	97	1	*BiasCmd*	Detector Bias Voltage (1=on)
12	98	1	*CalLow*	Electrical Calibration Range Low (1=enabled)
12	99	1	*CalHigh*	Electrical Calibration Range High (1=enabled)
12	100	1	*CalRate*	Calibration Rate (1=1953 events/sec; 0=8 events/sec)
12	101	6*1	*ProcDFlag*[6]	Detector Processing Enabled (1=enabled)

13	102	5	*LastCmd*	Address of Last Command to CRaTER
14	112	16	*LastValue*	Contents of Last Command to CRaTER
16	128	16	*DiscThin*	Low Level Discriminator Setting for Thin Detectors (D1, D3, D5)
18	144	16	*DiscThick*	Low Level Discriminator Setting for Thick Detectors (D2, D4, D6)
20	160	64*1	*Mask*[64]	Discriminator Accept Mask
28	224	6*16	*Single*[6]	Detector Singles Counter (one for each of 6 detectors)
40	320	16	*Good*	Good Events Counter
42	336	16	*Reject*	Rejected Events Counter
44	352	16	*Total*	Total Events Counter

Table 28: Format of Level 0 housekeeping data file records

Byte	Length (bits)	Name	Description	Units†
0	96	*Header*	Primary & Secondary Headers, ApId=122 (see Table 29)	
12	4	*FPGA_SN*	FPGA revision code	
12	12	*V28bus*	Spacecraft 28VDC bus voltage	0.00101*DN (V)
14	16	*V5digital*	+5VDC digital regulated voltage	0.00200*DN (V)
16	4	*VAnalog_Err*	= 15 if analog power is off (in which case, the remaining housekeeping fields are invalid); =0 otherwise	
16	12	*V5plus*	+5VDC analog regulated voltage	0.00200*DN (V)
18	16	*V5neg*	–5VDC analog regulated voltage	0.00201*DN (V)
20	16	*I28bus*	Instrument current drain off spacecraft bus	0.000198*DN (A)
22	6*16	*BiasCurrent*[6]	Detector bias current	0.00050*DN (μA)
34	16	*BiasVoltThin*	Thin detector (D1, D3, D5) bias voltage	0.101*DN (V)
36	16	*BiasVoltthick*	Thick detector (D2, D4, D6) bias voltage	0.101*DN (V)
38	16	*CalAmp*	Electrical calibration voltage amplitude	0.00100*DN (V)
40	16	*LLDThin*	Low Level Discriminator voltage for thin detectors (D1, D3, D5)	0.00124*DN – 0.124 (V)
42	16	*LLDThick*	Low Level Discriminator voltage for thick detectors (D2, D4, D6)	0.00124*DN – 0.124 (V)
44	16	*Ttelescope*	Temperature of telescope assembly	0.2**V5plus* – 0.100*DN – 273.2 (°C)
46	16	*Tanalog*	Temperature of analog electronics	0.2**V5plus* – 0.100*DN – 273.2 (°C)
48	16	*Tdigital*	Temperature of digital electronics	0.2**V5plus* – 0.100*DN – 273.2 (°C)
50	16	*Tpower*	Temperature of regulate power supply	0.2**V5plus* – 0.100*DN – 273.2 (°C)

52	16	*Tref*	Temperature of reference location on telescope wall	0.2**V5plus* – 0.100*DN – 273.2 (°C)
54	16	*RadHighSens*	High Sensitivity Radiation monitor voltage	0.00000125*DN (Rads)
56	16	*RadMedSens*	Medium Sensitivity Radiation monitor voltage	0.000320*DN (Rads)
58	16	*RadLowSens*	Low Sensitivity Radiation monitor voltage	0.08192*DN (Rads)
60	16	*Tprt*	Temperature of reference location on instrument chassis (ground test only)	0.1299*(4*DN–10000)/ (5–DN/1000) (°C)
62	16	*Purge*	Flow rate of GN2 purge (ground test only)	DN–0.371**V5plus*+ 19*(*Tref*–20) (CuFt/Hr)

† where "DN" is the unsigned integer value of the current field, *V5plus* is the value of the *V5plus* field converted to Volts, and *Tref* is the telescope wall temperature in °C. These relations between raw DN values and "engineering" units are only approximate. More accurate algorithms are used during pipeline processing to create Level 1 and 2 housekeeping products.

Table 29: Format of Level 0 record header structure

Byte	Bit	Length (bits)	Name	Description
0	0	3	*Version*	CCSDS Version Number
0	3	1	*PacketType*	Packet Type
1	4	1	*SecHdrFlag*	Secondary Header Flag (1=secondary header follows, bytes 6–11)
1	5	11	*ApId*	Application Process Identifier (120=primary science; 121=secondary science; 122=housekeeping)
2	16	2	*SegFlags*	Packet Segmentation Flags (3=no segmentation)
2	18	14	*SeqCount*	Source Sequence Count (separate for each ApId)
4	32	16	*PacketLength*	Packet Length (# bytes following primary header – 1)
6	48	1	*Reserved1*	Reserved (value=0)
6	49	31	*Time*	Spacecraft Time in Seconds (seconds elapsed since 1 January 2001 UT)
10	80	4	*FracTime*	Spacecraft Time in Fractional Seconds (1/16 second units)
10	84	5	*Reserved2*	Reserved (value=0)
11	89	1	*TestFlag*	Test Mode Flag (1=test enabled)
11	90	1	*OneHertz*	External One Hertz time sync pulse (1=not received)
11	91	5	*SerialNumber*	Instrument Serial Number

5.2.7 Level 1 data files

Level 1 data files contain the same information as their Level 0 counterparts, but translated into ASCII characters, with one addition: the primary science records contain the detector event energies converted to electron volts, alongside the raw count values from the Level 0 files. There are no header records and the format of the fixed-length, comma delimited, data records are shown in Table 30 to Table 32. The first column contains the byte offset of the start of the data field, and the second column lists the length of the field in bytes. Some fields contain multiple elements, denoted by the number within parentheses in column 3. The byte offset from the beginning of the record to the start of the *n*'th element is therefore $Col_1+(n-1)*(Col_2+1)$, where allowance has been made for the comma that follows every element.

Table 30: Format of Level 1 primary science data file records

Byte	Length (bytes)	Name	Fmt*	Units	Description
0	9	*Seconds*	I9	Secs	Interval from 0h UT Jan 1 2001 to 1Hz pulse
10	2	*Fract*	I2	Sec/100	Hundredths of a second from 1 Hz pulse
13	6	*Index*	I6	N/A	Index of event within the current second
20	4	*Ampl*[6]	I4	N/A	Amplitude in Detectors D1 to D6
50	10	*Energy*[6]	E10.4	eV	Energy deposited in Detectors D1 to D6

Table 31: Format of Level 1 secondary science data file records

Byte	Length (bytes)	Name	Fmt*	Units	Description
0	9	*Seconds*	I9	Secs	Interval from 0h UT Jan 1 2001 to 1Hz pulse
10	2	*Fract*	I2	Sec/100	Hundredths of a second from 1 Hz pulse
13	1	*BiasCntrl*	I1	N/A	Detector Bias Delayed Control (1=enabled)
15	1	*BiasCmd*	I1	N/A	Detector Bias Voltage (1=on)
17	1	*CalLow*	I1	N/A	Electrical Calibration Range Low (1=enabled)
19	1	*CalHigh*	I1	N/A	Electrical Calibration Range High (1=enabled)
21	1	*CalRate*	I1	N/A	Calibration Rate (1=1953, 0=8 events/sec)
23	1	*ProcDFlag*[6]	I1	N/A	Detector Processing Enabled (1=enabled)
35	5	*LastCmd*	I5	N/A	Address of Last Command to CRaTER
41	5	*LastValue*	I5	N/A	Contents of Last Command to CRaTER
47	5	*DiscThin*	I5	N/A	Low Level Discriminator Setting for Thin Detectors (D1, D3, D5)
53	5	*DiscThick*	I5	N/A	Low Level Discriminator Setting for Thick Detectors (D2, D4, D6)
59	10	*Mask*[2]	I10	N/A	Discriminator Accept Mask
81	5	*Single*[6]	I5	N/A	Detector Singles Counter (D1 to D6)
117	5	*Good*	I5	N/A	Good Events Counter
123	5	*Reject*	I5	N/A	Rejected Events Counter
129	5	*Total*	I5	N/A	Total Events Counter

Table 32: Format of Level 1 housekeeping data file records

Byte	Length (bytes)	Name	Fmt*	Units	Description
0	9	*Seconds*	I9	Secs	Intrerval from 0h UT Jan 1 2001 to 1hz pulse
10	2	*Fract*	I2	Sec/100	Hundredths of a second from 1 Hz pulse
13	2	*FPGA_SN*	I2	N/A	FPGA revision code
16	7	*V28bus*	F7.3	Volts	Spacecraft 28VDC bus voltage
24	7	*V5digital*	F7.3	Volts	+5VDC digital regulated voltage
32	2	*VAnalog_Err*	I2	N/A	= 15 if analog power is off (in which case, the remaining housekeeping fields are invalid); zero otherwise
35	7	*V5plus*	F7.3	Volts	+5VDC analog regulated voltage
43	7	*V5neg*	F7.3	Volts	–5VDC analog regulated voltage
51	7	*I28bus*	F7.3	Amps	Instrument current drain off spacecraft bus
59	7	*P28bus*	F7.3	Watts	Instrument power (*V28bus***I28bus*)
107	7	*BiasCurrent*[6]	F7.3	Amps	Detector bias current
115	7	*BiasVoltThin*	F7.3	Volts	Thin detector (D1, D3, D5) bias voltage
123	7	*BiasVoltthick*	F7.3	Volts	Thick detector (D2, D4, D6) bias voltage
131	7	*CalAmp*	F7.3	Volts	Electrical calibration voltage amplitude
139	7	*LLDThin*	F7.3	Volts	Low Level Discriminator voltage for thin detectors (D1, D3, D5)
147	7	*LLDThick*	F7.3	Volts	Low Level Discriminator voltage for thick detectors (D2, D4, D6)
155	7	*Ttelescope*	F7.2	°C	Temperature of telescope assembly
163	7	*Tanalog*	F7.2	°C	Temperature of analog electronics
171	7	*Tdigital*	F7.2	°C	Temperature of digital electronics
179	7	*Tpower*	F7.2	°C	Temperature of regulate power supply
187	7	*Tref*	F7.2	°C	Temperature of reference location on telescope wall
195	10	*RadHighSens*	E10.4	Rads	High Sensitivity Radiation monitor voltage
206	10	*RadMedSens*	E10.4	Rads	Medium Sensitivity Radiation monitor voltage
217	10	*RadLowSens*	E10.4	Rads	Low Sensitivity Radiation monitor voltage
228	10	*Tprt*	E10.4	°C	Temperature of reference location on instrument chassis (ground test only)
239	10	*Purge*	E10.4	cuFt/hr	Flow rate of GN2 purge (ground test only)

* The external representation of the field value as it would appear in a Fortran `FORMAT` statement.

5.2.8 Level 2 data files

Level 2 data files contain the same information as their Level 1 counterparts, with the following additions: the primary science records contain the Lineal Energy Transport of each detector event and the secondary science records contain geometrical information relating to the location and direction of the CRaTER instrument at one second intervals. In addition, all fields in the housekeeping files have been "conditioned", i.e., averaged over a predetermined time span, after minimum and maximum values were removed. There are no header records and the format of the fixed-length, comma delimited, data records are shown in Table 33 to Table 35. The first column contains the byte offset of the start of the data field, and the second column lists the length of the field in bytes. Some fields contain multiple elements, denoted by the number within parentheses in column 3. The byte offset from the beginning of the record to the start of the *n*'th element is therefore $Col_1+(n-1)*(Col_2+1)$, where allowance has been made for the comma that follows every element.

Table 33: Format of Level 2 primary science data file records

Byte	Length (bytes)	Name	Fmt*	Units	Description
0	9	*Seconds*	I9	Secs	Interval from 0h UT Jan 1 2001 to 1 Hz pulse
10	2	*Fract*	I2	Sec/100	Hundredths of a second from 1 Hz pulse
14	19	*Time*	A19	N/A	1 Hz Timing Pulse time in UTC
35	6	*Index*	I6	N/A	Index of event within the current second
42	4	*Ampl*[6]	I4	N/A	Amplitude in Detectors D1 to D6
72	10	*Energy*[6]	E10.4	eV	Energy deposited in Detectors D1 to D6
138	10	*LET*[6]	E10.4	eV/µm	Lineal Energy Transfer in silicon in Detectors D1 to D6
204	10	*DQI*	E10.4	N/A	Data quality indicator
215	1	*Flags*[32]	I1	N.A	Flag fields

Table 34: Format of Level 2 secondary science data file records

Byte	Length (bytes)	Name	Fmt*	Units	Description
0	9	*Seconds*	I9	Secs	Interval from 0h UT Jan 1 2001 to 1 Hz pulse
10	2	*Fract*	I2	Sec/100	Hundredths of a second from 1 Hz pulse
14	19	*Time*	A19	N/A	1 Hz Timing Pulse time in UTC
35	1	*BiasCntrl*	I1	N/A	Detector Bias Delayed Control (1=enabled)
37	1	*BiasCmd*	I1	N/A	Detector Bias Voltage (1=on)
39	1	*CalLow*	I1	N/A	Electrical Calibration Range Low (1=enabled)
41	1	*CalHigh*	I1	N/A	Electrical Cal. Range High (1=enabled)
43	1	*CalRate*	I1	N/A	Calibration Rate (1=1953, 0=8 events/sec)
45	1	*ProcDFlag*[6]	I1	N/A	Detector Processing Enabled (1=enabled)
57	5	*LastCmd*	I5	N/A	Address of Last Command to CRaTER
63	5	*LastValue*	I5	N/A	Contents of Last Command to CRaTER
69	5	*DiscThin*	I5	N/A	Low Level Discriminator Setting for Thin Detectors (D1, D3, D5)
75	5	*DiscThick*	I5	N/A	Low Level Discriminator Setting for Thick Detectors (D2, D4, D6)
81	10	*Mask*[2]	I10	N/A	Discriminator Accept Mask
103	5	*Single*[6]	I5	N/A	Detector Singles Counter (D1 to D6)
139	5	*Good*	I5	N/A	Good Events Counter
145	5	*Reject*	I5	N/A	Rejected Events Counter
151	5	*Total*	I5	N/A	Total Events Counter
157	11	*MoonVec*[3]	E11.4	Km	Spacecraft to Moon vector (J2000)
193	11	*SunVec*[3]	E11.4	Km	Spacecraft to Sun vector (J2000)
229	11	*CraterVec*[3]	E11.4	N/A	CRaTER boresight unit vector (J2000)
265	11	*Altitude*	E11.4	Km	Altitude above lunar surface (J2000)

277	11	*Nadir*	E11.4	Deg	Angle between CRaTER boresight and nadir
289	11	*GSEVec*[3]	E11.4	Km	Sun to CRaTER vector (GSE coordinates)
325	11	*GSMVec*[3]	E11.4	Km	Earth to CRaTER vector (GSM coordinates)
361	11	*Latitude*	E11.4	Deg	Selenocentric S/C latitude (IAU)
373	11	*Longitude*	E11.4	Deg	Selenocentric S/C longitude (IAU)

Table 35: Format of Level 2 housekeeping data file records

Byte	Length (bytes)	Name	Fmt*	Units	Description
0	9	*Seconds*	I9	Secs	Interval from 0h UT Jan 1 2001 to 1 Hz pulse
10	2	*Fract*	I2	Sec/100	Hundredths of a second from 1 Hz pulse
14	19	*Time*	A19	N/A	1 Hz Timing Pulse time in UTC
35	2	*FPGA_SN*	I2	N/A	FPGA revision code
38	7	*V28bus*	F7.3	Volts	Spacecraft 28VDC bus voltage
46	7	*V5digital*	F7.3	Volts	+5VDC digital regulated voltage
54	2	*VAnalog_Err*	I2	N/A	= 15 if analog power is off (& remaining H/K fields are invalid); zero otherwise
57	7	*V5plus*	F7.3	Volts	+5VDC analog regulated voltage
65	7	*V5neg*	F7.3	Volts	–5VDC analog regulated voltage
73	7	*I28bus*	F7.3	Amps	Instrument current drain off spacecraft bus
81	7	*P28bus*	F7.3	Watts	Instrument power (*V28bus***I28bus*)
129	7	*BiasCurrent*[6]	F7.3	Amps	Detector bias current
137	7	*BiasVoltThin*	F7.3	Volts	Thin detector (D1, D3, D5) bias voltage
145	7	*BiasVolTthick*	F7.3	Volts	Thick detector (D2, D4, D6) bias voltage
153	7	*CalAmp*	F7.3	Volts	Electrical calibration voltage amplitude
161	7	*LLDThin*	E10.4	eV	Low Level Discriminator energy for thin detectors (D1, D3, D5)
169	7	*LLDThick*	E10.4	eV	Low Level Discriminator energy for thick detectors (D2, D4, D6)
177	7	*Ttelescope*	F7.2	°C	Temperature of telescope assembly
185	7	*Tanalog*	F7.2	°C	Temperature of analog electronics
193	7	*Tdigital*	F7.2	°C	Temperature of digital electronics
201	7	*Tpower*	F7.2	°C	Temperature of regulate power supply
209	7	*Tref*	F7.2	°C	Temperature of reference location on telescope wall
217	10	*RadHighSens*	E10.4	Rads	High Sensitivity Radiation monitor voltage
228	10	*RadMedSens*	E10.4	Rads	Medium Sensitivity Radiation monitor volts
239	10	*RadLowSens*	E10.4	Rads	Low Sensitivity Radiation monitor voltage
250	10	*Tprt*	E10.4	°C	Temperature of reference location on instrument chassis (ground test only)
261	10	*Purge*	E10.4	cuFt/hr	Flow rate of GN2 purge (ground test only)
272	10	*Radtotal*	E10.4	Rads	Cumulative instrument radiation dosage
283	10	*BiasEnergy*[6]	E10.4	Volts	Detector bias energies

* The external representation of the field value as it would appear in a Fortran `FORMAT` statement.

Appendix A Support staff and cognizant persons

Table 36: Archive collection support staff

CRaTER team			
Name	**Address**	**Phone**	**Email**
Prof. Harlan Spence Principal Investigator	Boston University Department of Astronomy CAS Room 410 725 Commonwealth Ave. Boston MA 02215 USA	+001 617 353-7421	spence@bu.edu
Dr. Justin Kasper Project Scientist	Harvard–Smithsonian Astrophysical Observatory, MS–58, 60 Garden St, Cambridge MA 02138 USA	+001 617 496-7875	jkasper@cfa.harvard.edu
Dr. Michael Golightly Deputy Project Scientist SOC Lead (from 2008)	Boston University Department of Astronomy CAS Room 406 725 Commonwealth Ave. Boston MA 02215 USA	+001 617 358-4864	mgolight@bu.edu
Dr. Peter Ford SOC Lead (through 2007)	MIT 37-571 70 Vassar Street Cambridge MA 02139-4307 USA	+001 617 253-6485	pgf@space.mit.edu
Mr. Robert Goeke Project Engineer	MIT NE80-6099 1 Hampshire Street Cambridge MA 02139 USA	+001 617 253-1910	goeke@space.mit.edu
Ms Joan Quigley Data Processing Developer	MIT 37-662C 70 Vassar Street Cambridge MA 02139-4307 USA	+001 617 253-4287	jcq@space.mit.edu

UCLA			
Name	**Address**	**Phone**	**Email**
Mr. Steven Joy PPI Operations Manager	IGPP, University of California 405 Hilgard Avenue Los Angeles, CA 90095-1567 USA	+001 310 825 3506	sjoy@igpp.ucla.edu
Mr. Mark Sharlow PPI Data Engineer	IGPP, University of California 405 Hilgard Avenue Los Angeles, CA 90095-1567 USA	+001 310 206 6073	msharlow@igpp.ucla.edu

Appendix B PDS label files

All CRaTER instrument data files are accompanied by PDS label files, possessing the same names are the files they describe, but with the extension LBL. The basic content for these label files is as follows, where the NOTE field is reserved for product-specific comments:

B.1 Level 0 Primary Science Data Label File

```
PDS_VERSION_ID                = PDS3
DATA_SET_ID                   = "LRO-L-CRAT-2-EDR-RAWDATA-V1.0"
DATA_SET_NAME                 = "LRO CRATER RAW LUNAR DATA V1.0"
STANDARD_DATA_PRODUCT_ID      = "CRAT_L0_PRI"
PRODUCT_ID                    = "CRAT_L0_PRI_yyyyddd_Vnn"
PRODUCT_TYPE                  = EDR
PRODUCT_VERSION_ID            = "n.n"
PRODUCT_CREATION_TIME         = yyyy-mm-ddThh:mm:ss.sss
MISSION_PHASE                 = "cccccccc"
RECORD_FORMAT                 = UNDEFINED
FILE_RECORDS                  = nnnnn
START_TIME                    = yyyy-mm-ddThh:mm:ss.sss
STOP_TIME                     = yyyy-mm-ddThh:mm:ss.sss
SPACECRAFT_CLOCK_START_COUNT  = "ssssssssss.ss"
SPACECRAFT_CLOCK_STOP_COUNT   = "ssssssssss.ss"
INSTRUMENT_HOST_NAME          = "Lunar Reconnaissance Orbiter"
INSTRUMENT_HOST_ID            = "LRO"
INSTRUMENT_NAME               = "Cosmic Ray Telescope for the Effects of
                                Radiation"
INSTRUMENT_ID                 = "CRAT"
INSTRUMENT_SERIAL_NUMBER      = n
DESCRIPTION                   = "CRaTER consists of a stack of 6 charged
                                Particle detectors embedded within structures
                                of aluminum and plastic. It investigates the
                                effect of galactic cosmic rays and high-energy
                                solar particles on tissue-equivalent plastics
                                as a constraint on models of biological
                                response to background space radiation."
NOTE                          = "optional text comment"
^TABLE                        = "CRAT_L0_PRI_yyyyddd_Vnn.DAT"
OBJECT                        = TABLE
    NAME                      = LROHDR
    INTERCHANGE_FORMAT        = BINARY
    BYTES                     = 64
    ROWS                      = 1
    COLUMNS                   = 7
    ^STRUCTURE                = "LROHDR.FMT"
    DESCRIPTION               = "LRO standard 64-byte header."
END_OBJECT                    = TABLE
^TABLE                        = ("CRAT_L0_PRI_yyyyddd_Vnn.DAT",64 <BYTES>)
OBJECT                        = TABLE
    NAME                      = CRAT_L0_PRI
    INTERCHANGE_FORMAT        = BINARY
    ROWS                      = nnnnn
    ROW_BYTES                 = 444
    COLUMNS                   = 2
    ^STRUCTURE                = "CRAT_L0_PRI.FMT"
    DESCRIPTION               = "CRaTER Instrument Primary Science packets.
                                The byte length of each varying-length packet
                                is 7 plus the value of the fourth 16-bit
```

```
                              unsigned MSB integer in the packet."
END_OBJECT                    = TABLE
END
```

B.2 Level 0 Secondary Science Data Label File

```
PDS_VERSION_ID                = PDS3
DATA_SET_ID                   = "LRO-L-CRAT-2-EDR-RAWDATA-V1.0"
DATA_SET_NAME                 = "LRO CRATER RAW LUNAR DATA V1.0"
STANDARD_DATA_PRODUCT_ID      = "CRAT_L0_SEC"
PRODUCT_ID                    = "CRAT_L0_SEC_yyyyddd_Vnn"
PRODUCT_TYPE                  = EDR
PRODUCT_VERSION_ID            = "n.n"
PRODUCT_CREATION_TIME         = yyyy-mm-ddThh:mm:ss.sss
MISSION_PHASE                 = "cccccccc"
RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 46
FILE_RECORDS                  = nnnnn
START_TIME                    = yyyy-mm-ddThh:mm:ss.sss
STOP_TIME                     = yyyy-mm-ddThh:mm:ss.sss
SPACECRAFT_CLOCK_START_COUNT  = "ssssssssss.ss"
SPACECRAFT_CLOCK_STOP_COUNT   = "ssssssssss.ss"
INSTRUMENT_HOST_NAME          = "Lunar Reconnaissance Orbiter"
INSTRUMENT_HOST_ID            = "LRO"
INSTRUMENT_NAME               = "Cosmic Ray Telescope for the Effects of
                                Radiation"
INSTRUMENT_ID                 = "CRAT"
INSTRUMENT_SERIAL_NUMBER      = n
DESCRIPTION                   = "CRaTER consists of a stack of 6 charged
                                Particle detectors embedded within structures
                                of aluminum and plastic. It investigates the
                                effect of galactic cosmic rays and high-energy
                                solar particles on tissue-equivalent plastics
                                as a constraint on models of biological
                                response to background space radiation."
NOTE                          = "optional text comment"
^TABLE                        = "CRAT_L0_SEC_yyyyddd_Vnn.DAT"
OBJECT                        = TABLE
    NAME                      = LROHDR
    INTERCHANGE_FORMAT        = BINARY
    BYTES                     = 64
    COLUMNS                   = 7
    ^STRUCTURE                = "LROHDR.FMT"
    DESCRIPTION               = "LRO standard 64-byte header, followed by 28
                                NUL bytes (0x00)."
END_OBJECT                    = TABLE
^TABLE                        = ("CRAT_L0_SEC_yyyyddd_Vnn.DAT",3)
OBJECT                        = TABLE
    NAME                      = CRAT_L0_SEC
    INTERCHANGE_FORMAT        = BINARY
    ROWS                      = nnnnn
    COLUMNS                   = 9
    ROW_BYTES                 = 46
    ^STRUCTURE                = "CRAT_L0_SEC.FMT"
    DESCRIPTION               = "CRaTER Instrument Secondary Science packets."
END_OBJECT                    = TABLE
END
```

B.3 Level 0 Housekeeping Data Label File

```
PDS_VERSION_ID                 = PDS3
DATA_SET_ID                    = "LRO-L-CRAT-2-EDR-RAWDATA-V1.0"
DATA_SET_NAME                  = "LRO CRATER RAW LUNAR DATA V1.0"
STANDARD_DATA_PRODUCT_ID       = "CRAT_L0_HK"
PRODUCT_ID                     = "CRAT_L0_HK_yyyyddd_Vnn"
PRODUCT_TYPE                   = EDR
PRODUCT_VERSION_ID             = "n.n"
PRODUCT_CREATION_TIME          = yyyy-mm-ddThh:mm:ss.sss
MISSION_PHASE                  = "cccccccc"

RECORD_TYPE                    = FIXED_LENGTH
RECORD_BYTES                   = 64
FILE_RECORDS                   = nnnnn

START_TIME                     = yyyy-mm-ddThh:mm:ss.sss
STOP_TIME                      = yyyy-mm-ddThh:mm:ss.sss
SPACECRAFT_CLOCK_START_COUNT = "ssssssssss.ss"
SPACECRAFT_CLOCK_STOP_COUNT  = "ssssssssss.ss"

INSTRUMENT_HOST_NAME           = "Lunar Reconnaissance Orbiter"
INSTRUMENT_HOST_ID             = "LRO"
INSTRUMENT_NAME                = "Cosmic Ray Telescope for the Effects of
                                 Radiation"
INSTRUMENT_ID                  = "CRAT"
INSTRUMENT_SERIAL_NUMBER       = n
DESCRIPTION                    = "CRaTER consists of a stack of 6 charged
                                 Particle detectors embedded within structures
                                 of aluminum and plastic. It investigates the
                                 effect of galactic cosmic rays and high-energy
                                 solar particles on tissue-equivalent plastics
                                 as a constraint on models of biological
                                 response to background space radiation."

NOTE                           = "optional text comment"

^TABLE                         = "CRAT_L0_HK_yyyyddd_Vnn.DAT"
OBJECT                         = TABLE
    INTERCHANGE_FORMAT         = BINARY
    BYTES                      = 64
    ROWS                       = 1
    COLUMNS                    = 7
    ^STRUCTURE                 = "LROHDR.FMT"
    DESCRIPTION                = "LRO standard 64-byte header."
END_OBJECT                     = TABLE

^TABLE                         = ("CRAT_L0_HK_yyyyddd_Vnn.DAT",2)
OBJECT                         = TABLE
    NAME                       = CRAT_L0_HK
    INTERCHANGE_FORMAT         = BINARY
    ROWS                       = nnnnn
    COLUMNS                    = 22
    ROW_BYTES                  = 64
    ^STRUCTURE                 = "CRAT_L0_HK.FMT"
    DESCRIPTION                = "CRaTER Instrument Housekeeping packets."
END_OBJECT                     = TABLE

END
```

B.4 Level 1 Primary Science Data Label File

```
PDS_VERSION_ID                = PDS3
DATA_SET_ID                   = "LRO-L-CRAT-3-CDR_CALIBRATED-V1.0"
DATA_SET_NAME                 = "LRO CRATER CALIBRATED LUNAR ENERGY DATA V1.0"
STANDARD_DATA_PRODUCT_ID      = "CRAT_L1_PRI"
PRODUCT_ID                    = "CRAT_L1_PRI_yyyyddd_Vnn"
PRODUCT_TYPE                  = RDR
PRODUCT_VERSION_ID            = "n.n"
PRODUCT_CREATION_TIME         = yyyy-mm-ddThh:mm:ss.sss
MISSION_PHASE                 = "cccccccc"

RECORD_FORMAT                 = FIXED_LENGTH
RECORD_BYTES                  = 118
FILE_RECORDS                  = nnnnn

START_TIME                    = yyyy-mm-ddThh:mm:ss.sss
STOP_TIME                     = yyyy-mm-ddThh:mm:ss.sss
SPACECRAFT_CLOCK_START_COUNT = "ssssssssss.ss"
SPACECRAFT_CLOCK_STOP_COUNT   = "ssssssssss.ss"

INSTRUMENT_HOST_NAME          = "Lunar Reconnaissance Orbiter"
INSTRUMENT_HOST_ID            = "LRO"
INSTRUMENT_NAME               = "Cosmic Ray Telescope for the Effects of
                                Radiation"
INSTRUMENT_ID                 = "CRAT"
INSTRUMENT_SERIAL_NUMBER      = n
DESCRIPTION                   = "CRaTER consists of a stack of 6 charged
                                Particle detectors embedded within structures
                                of aluminum and plastic. It investigates the
                                effect of galactic cosmic rays and high-energy
                                solar particles on tissue-equivalent plastics
                                as a constraint on models of biological
                                response to background space radiation."

NOTE                          = "optional text comment"

^TABLE                        = "CRAT_L1_PRI_yyyyddd_Vnn.TAB"
OBJECT                        = TABLE
    NAME                      = CRAT_L1_PRI
    INTERCHANGE_FORMAT        = ASCII
    ROWS                      = nnnnn
    COLUMNS                   = 5
    ROW_BYTES                 = 118
    ^STRUCTURE                = "CRAT_L1_PRI.FMT"
    DESCRIPTION               = "CRaTER Instrument Level 1 Primary Science."
END_OBJECT                    = TABLE

END
```

B.5 Level 1 Secondary Science Data Label File

```
PDS_VERSION_ID               = PDS3
DATA_SET_ID                  = "LRO-L-CRAT-3-CDR_CALIBRATED-V1.0"
DATA_SET_NAME                = "LRO CRATER CALIBRATED LUNAR ENERGY DATA V1.0"

STANDARD_DATA_PRODUCT_ID     = "CRAT_L1_SEC"
PRODUCT_ID                   = "CRAT_L1_SEC_yyyyddd_Vnn"
PRODUCT_TYPE                 = RDR
PRODUCT_VERSION_ID           = "n.n"
PRODUCT_CREATION_TIME        = yyyy-mm-ddThh:mm:ss.sss
MISSION_PHASE                = "cccccccc"

RECORD_TYPE                  = FIXED_LENGTH
RECORD_BYTES                 = 136
FILE_RECORDS                 = nnnnn

START_TIME                   = yyyy-mm-ddThh:mm:ss.sss
STOP_TIME                    = yyyy-mm-ddThh:mm:ss.sss
SPACECRAFT_CLOCK_START_COUNT = "ssssssssss.ss"
SPACECRAFT_CLOCK_STOP_COUNT  = "ssssssssss.ss"

INSTRUMENT_HOST_NAME         = "Lunar Reconnaissance Orbiter"
INSTRUMENT_HOST_ID           = "LRO"
INSTRUMENT_NAME              = "Cosmic Ray Telescope for the Effects of
                               Radiation"
INSTRUMENT_ID                = "CRAT"
INSTRUMENT_SERIAL_NUMBER     = n
DESCRIPTION                  = "CRaTER consists of a stack of 6 charged
                               Particle detectors embedded within structures
                               of aluminum and plastic. It investigates the
                               effect of galactic cosmic rays and high-energy
                               solar particles on tissue-equivalent plastics
                               as a constraint on models of biological
                               response to background space radiation."

NOTE                         = "optional text comment"

^TABLE                       = "CRAT_L1_SEC_yyyyddd_Vnn.TAB"
OBJECT                       = TABLE
    NAME                     = CRAT_L1_SEC
    INTERCHANGE_FORMAT       = ASCII
    ROWS                     = nnnnn
    COLUMNS                  = 17
    ROW_BYTES                = 136
    ^STRUCTURE               = "CRAT_L1_SEC.FMT"
    DESCRIPTION              = "CRaTER Instrument Level 1 Secondary Science."
END_OBJECT                   = TABLE

END
```

B.6 Level 1 Housekeeping Data Label File

```
PDS_VERSION_ID                = PDS3
DATA_SET_ID                   = "LRO-L-CRAT-3-CDR_CALIBRATED-V1.0"
DATA_SET_NAME                 = "LRO CRATER CALIBRATED LUNAR ENERGY DATA V1.0"

STANDARD_DATA_PRODUCT_ID      = "CRAT_L1_HK"
PRODUCT_ID                    = "CRAT_L1_HK_yyyyddd_Vnn"
PRODUCT_TYPE                  = RDR
PRODUCT_VERSION_ID            = "n.n"
PRODUCT_CREATION_TIME         = yyyy-mm-ddThh:mm:ss.sss
MISSION_PHASE                 = "cccccccc"

RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 252
FILE_RECORDS                  = nnnnn

START_TIME                    = yyyy-mm-ddThh:mm:ss.sss
STOP_TIME                     = yyyy-mm-ddThh:mm:ss.sss
SPACECRAFT_CLOCK_START_COUNT  = "ssssssssss.ss"
SPACECRAFT_CLOCK_STOP_COUNT   = "ssssssssss.ss"

INSTRUMENT_HOST_NAME          = "Lunar Reconnaissance Orbiter"
INSTRUMENT_HOST_ID            = "LRO"
INSTRUMENT_NAME               = "Cosmic Ray Telescope for the Effects of
                                Radiation"
INSTRUMENT_ID                 = "CRAT"
INSTRUMENT_SERIAL_NUMBER      = n
DESCRIPTION                   = "CRaTER consists of a stack of 6 charged
                                Particle detectors embedded within structures
                                of aluminum and plastic. It investigates the
                                effect of galactic cosmic rays and high-energy
                                solar particles on tissue-equivalent plastics
                                as a constraint on models of biological
                                response to background space radiation."

NOTE                          = "optional text comment"

^TABLE                        = "CRAT_L1_HK_yyyyddd_Vnn.TAB"
OBJECT                        = TABLE
    NAME                      = CRAT_L1_HK
    INTERCHANGE_FORMAT        = ASCII
    ROWS                      = nnnnn
    COLUMNS                   = 26
    ROW_BYTES                 = 252
    ^STRUCTURE                = "CRAT_L1_HK.FMT"
    DESCRIPTION               = "CRaTER Instrument Level 1 Housekeeping."
END_OBJECT                    = TABLE

END
```

B.7 Level 2 Primary Science Data Label File

```
PDS_VERSION_ID                = PDS3
DATA_SET_ID                   = "LRO-L-CRAT-3/4-DDR-PROCESSED-V1.0"
DATA_SET_NAME                 = "LRO CRATER CALIBRATED LUNAR LET DATA V1.0"
STANDARD_DATA_PRODUCT_ID      = "CRAT_L2_PRI"
PRODUCT_ID                    = "CRAT_L2_PRI_yyyyddd_Vnn"
PRODUCT_TYPE                  = RDR
PRODUCT_VERSION_ID            = "n.n"
PRODUCT_CREATION_TIME         = yyyy-mm-ddThh:mm:ss.sss
MISSION_PHASE                 = "cccccccc"

RECORD_FORMAT                 = FIXED_LENGTH
RECORD_BYTES                  = 280
FILE_RECORDS                  = nnnnn

START_TIME                    = yyyy-mm-ddThh:mm:ss.sss
STOP_TIME                     = yyyy-mm-ddThh:mm:ss.sss
SPACECRAFT_CLOCK_START_COUNT  = "ssssssssss.ss"
SPACECRAFT_CLOCK_STOP_COUNT   = "ssssssssss.ss"

INSTRUMENT_HOST_NAME          = "Lunar Reconnaissance Orbiter"
INSTRUMENT_HOST_ID            = "LRO"
INSTRUMENT_NAME               = "Cosmic Ray Telescope for the Effects of
                                Radiation"
INSTRUMENT_ID                 = "CRAT"
INSTRUMENT_SERIAL_NUMBER      = n
DESCRIPTION                   = "CRaTER consists of a stack of 6 charged
                                Particle detectors embedded within structures
                                of aluminum and plastic. It investigates the
                                effect of galactic cosmic rays and high-energy
                                solar particles on tissue-equivalent plastics
                                as a constraint on models of biological
                                response to background space radiation."

NOTE                          = "optional text comment"

^TABLE                        = "CRAT_L2_PRI_yyyyddd_Vnn.TAB"
OBJECT                        = TABLE
    NAME                      = CRAT_L2_PRI
    INTERCHANGE_FORMAT        = ASCII
    ROWS                      = nnnnn
    COLUMNS                   = 9
    ROW_BYTES                 = 280
    ^STRUCTURE                = "CRAT_L2_PRI.FMT"
    DESCRIPTION               = "CRaTER Instrument Level 2 Primary Science."
END_OBJECT                    = TABLE

END
```

B.8 Level 2 Secondary Science Data Label File

```
PDS_VERSION_ID                = PDS3
DATA_SET_ID                   = "LRO-L-CRAT-3/4-DDR-PROCESSED-V1.0"
DATA_SET_NAME                 = "LRO CRATER CALIBRATED LUNAR LET DATA V1.0"
STANDARD_DATA_PRODUCT_ID      = "CRAT_L2_SEC"
PRODUCT_ID                    = "CRAT_L2_SEC_yyyyddd_Vnn"
PRODUCT_TYPE                  = RDR
PRODUCT_VERSION_ID            = "n.n"
PRODUCT_CREATION_TIME         = yyyy-mm-ddThh:mm:ss.sss
MISSION_PHASE                 = "cccccccc"

RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 386
FILE_RECORDS                  = nnnnn

START_TIME                    = yyyy-mm-ddThh:mm:ss.sss
STOP_TIME                     = yyyy-mm-ddThh:mm:ss.sss
SPACECRAFT_CLOCK_START_COUNT = "ssssssssss.ss"
SPACECRAFT_CLOCK_STOP_COUNT  = "ssssssssss.ss"

INSTRUMENT_HOST_NAME          = "Lunar Reconnaissance Orbiter"
INSTRUMENT_HOST_ID            = "LRO"
INSTRUMENT_NAME               = "Cosmic Ray Telescope for the Effects of
                                Radiation"
INSTRUMENT_ID                 = "CRAT"
INSTRUMENT_SERIAL_NUMBER      = n
DESCRIPTION                   = "CRaTER consists of a stack of 6 charged
                                Particle detectors embedded within structures
                                of aluminum and plastic. It investigates the
                                effect of galactic cosmic rays and high-energy
                                solar particles on tissue-equivalent plastics
                                as a constraint on models of biological
                                response to background space radiation."

NOTE                          = "optional text comment"

^TABLE                        = "CRAT_L2_SEC_yyyyddd_Vnn.TAB"
OBJECT                        = TABLE
    NAME                      = CRAT_L2_SEC
    INTERCHANGE_FORMAT        = ASCII
    ROWS                      = nnnnn
    COLUMNS                   = 27
    ROW_BYTES                 = 386
    ^STRUCTURE                = "CRAT_L2_SEC.FMT"
    DESCRIPTION               = "CRaTER Instrument Level 2 Secondary Science."
END_OBJECT                    = TABLE

END
```

B.9 Level 2 Housekeeping Data Label File

```
PDS_VERSION_ID                = PDS3
DATA_SET_ID                   = "LRO-L-CRAT-3/4-DDR-PROCESSED-V1.0"
DATA_SET_NAME                 = "LRO CRATER CALIBRATED LUNAR LET DATA V1.0"
STANDARD_DATA_PRODUCT_ID      = "CRAT_L2_HK"
PRODUCT_ID                    = "CRAT_L2_HK_yyyyddd_Vnn"
PRODUCT_TYPE                  = RDR
PRODUCT_VERSION_ID            = "n.n"
PRODUCT_CREATION_TIME         = yyyy-mm-ddThh:mm:ss.sss
MISSION_PHASE                 = "cccccccc"

RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 306
FILE_RECORDS                  = nnnnn

START_TIME                    = yyyy-mm-ddThh:mm:ss.sss
STOP_TIME                     = yyyy-mm-ddThh:mm:ss.sss
SPACECRAFT_CLOCK_START_COUNT = "ssssssssss.ss"
SPACECRAFT_CLOCK_STOP_COUNT  = "ssssssssss.ss"

INSTRUMENT_HOST_NAME          = "Lunar Reconnaissance Orbiter"
INSTRUMENT_HOST_ID            = "LRO"
INSTRUMENT_NAME               = "Cosmic Ray Telescope for the Effects of
                                Radiation"
INSTRUMENT_ID                 = "CRAT"
INSTRUMENT_SERIAL_NUMBER      = n
DESCRIPTION                   = "CRaTER consists of a stack of 6 charged
                                Particle detectors embedded within structures
                                of aluminum and plastic. It investigates the
                                effect of galactic cosmic rays and high-energy
                                solar particles on tissue-equivalent plastics
                                as a constraint on models of biological
                                response to background space radiation."

NOTE                          = "text comment"

^TABLE                        = "CRAT_L2_HK_yyyyddd_Vnn.TAB"
OBJECT                        = TABLE
    NAME                      = CRAT_L2_HK
    INTERCHANGE_FORMAT        = ASCII
    ROWS                      = nnnnn
    COLUMNS                   = 30
    ROW_BYTES                 = 306
    ^STRUCTURE                = "CRAT_L2_HK.FMT"
    DESCRIPTION               = "CRaTER Instrument Level 2 Housekeeping."
END_OBJECT                    = TABLE

END
```

Appendix C Level 0 data record formats

The files comprising CRaTER standard products have record formats that are specified in the PDS label files and in the accompanying `FMT` files located in the `LABEL` directory. This section shows the format component of PDS labels for each of the three types of Level 0 binary data file.

C.1 Level 0 64-byte Binary File Header Record (LROHDR.FMT)

```
OBJECT                  = COLUMN
  NAME                  = FILEID
  COLUMN_NUMBER         = 1
  START_BYTE            = 1
  BYTES                 = 4
  DATA_TYPE             = MSB_UNSIGNED_INTEGER
  MINIMUM               = 200
  MAXIMUM               = 202
  DESCRIPTION           = "Numerical file identifier (primary science = 200,
                          housekeeping = 201, secondary science = 202)."
END_OBJECT              = COLUMN
OBJECT                  = COLUMN
  NAME                  = RESERVED
  COLUMN_NUMBER         = 2
  START_BYTE            = 5
  BYTES                 = 4
  DATA_TYPE             = MSB_UNSIGNED_INTEGER
  MINIMUM               = 0
  MAXIMUM               = 0
  DESCRIPTION           = "Spare."
END_OBJECT              = COLUMN
OBJECT                  = COLUMN
  NAME                  = STARTTIMESEC
  COLUMN_NUMBER         = 3
  START_BYTE            = 9
  BYTES                 = 4
  DATA_TYPE             = MSB_UNSIGNED_INTEGER
  UNIT                  = SECONDS
  MINIMUM               = 0
  MAXIMUM               = 2147483647
  DESCRIPTION           = "Spacecraft time of first packet in the file (seconds
                          from Jan 1 2001 UTC)."
END_OBJECT              = COLUMN
OBJECT                  = COLUMN
  NAME                  = STARTTIMESUBSEC
  COLUMN_NUMBER         = 4
  START_BYTE            = 13
  BYTES                 = 4
  DATA_TYPE             = MSB_UNSIGNED_INTEGER
  UNIT                  = "2^-32 SECONDS"
  MINIMUM               = 0
  MAXIMUM               = 2147483647
  DESCRIPTION           = "Fractional spacecraft time of first packet."
END_OBJECT              = COLUMN
OBJECT                  = COLUMN
  NAME                  = STOPTIMESEC
  COLUMN_NUMBER         = 5
  START_BYTE            = 17
  BYTES                 = 4
  DATA_TYPE             = MSB_UNSIGNED_INTEGER
```

```
  UNIT                = SECONDS
  MINIMUM             = 0
  MAXIMUM             = 2147483647
  DESCRIPTION         = "Spacecraft time of last packet in the file (seconds
                        from Jan 1 2001 UTC)."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = STOPTIMESUBSEC
  COLUMN_NUMBER       = 6
  START_BYTE          = 21
  BYTES               = 4
  DATA_TYPE           = MSB_UNSIGNED_INTEGER
  UNIT                = "2^-32 SECONDS"
  MINIMUM             = 0
  MAXIMUM             = 2147483647
  DESCRIPTION         = "Fractional spacecraft time of last packet."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = FILENAME
  COLUMN_NUMBER       = 7
  START_BYTE          = 25
  BYTES               = 40
  DATA_TYPE           = CHARACTER
  DESCRIPTION         = "Name of the data product in uppercase characters."
END_OBJECT            = COLUMN
```

C.2 Level 0 Binary Record Header (CRAT_L0_HDR.FMT)

```
OBJECT                = BIT_COLUMN
  NAME                = VERSION
  COLUMN_NUMBER       = 1
  START_BIT           = 1
  BITS                = 3
  BIT_DATA_TYPE       = MSB_UNSIGNED_INTEGER
  MINIMUM             = 0
  MAXIMUM             = 0
  DESCRIPTION         = "CCSDS Version Number."
END_OBJECT            = BIT_COLUMN
OBJECT                = BIT_COLUMN
  NAME                = PACKETTYPE
  COLUMN_NUMBER       = 2
  START_BIT           = 4
  BITS                = 1
  BIT_DATA_TYPE       = MSB_UNSIGNED_INTEGER
  MINIMUM             = 0
  MAXIMUM             = 0
  DESCRIPTION         = "Packet Type."
END_OBJECT            = BIT_COLUMN
OBJECT                = BIT_COLUMN
  NAME                = SECHDRFLAG
  COLUMN_NUMBER       = 3
  START_BIT           = 5
  BITS                = 1
  BIT_DATA_TYPE       = MSB_UNSIGNED_INTEGER
  MINIMUM             = 1
  MAXIMUM             = 1
  DESCRIPTION         = "Secondary Header Flag (1 = secondary header
                        follows)."
```

```
END_OBJECT           = BIT_COLUMN
OBJECT               = BIT_COLUMN
  NAME               = APID
  COLUMN_NUMBER      = 4
  START_BIT          = 6
  BITS               = 11
  BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
  MINIMUM            = 120
  MAXIMUM            = 122
  DESCRIPTION        = "Application Process ID (120 = primary science; 121 =
                       secondary science; 122 = housekeeping)."
END_OBJECT           = BIT_COLUMN
OBJECT               = BIT_COLUMN
  NAME               = SEGFLAGS
  COLUMN_NUMBER      = 5
  START_BIT          = 17
  BITS               = 2
  BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
  MINIMUM            = 3
  MAXIMUM            = 3
  DESCRIPTION        = "Packet Segmentation Flags (3 = no segmentation)."
END_OBJECT           = BIT_COLUMN
OBJECT               = BIT_COLUMN
  NAME               = SEQCOUNT
  COLUMN_NUMBER      = 6
  START_BIT          = 19
  BITS               = 14
  BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
  MINIMUM            = 0
  MAXIMUM            = 16383
  DESCRIPTION        = "Sources Sequence Count (separate for each ApId)."
END_OBJECT           = BIT_COLUMN
OBJECT               = BIT_COLUMN
  NAME               = PACKETLENGTH
  COLUMN_NUMBER      = 7
  START_BIT          = 33
  BITS               = 16
  BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
  MINIMUM            = 0
  MAXIMUM            = 441
  DESCRIPTION        = "Packet Length (number of bytes following primary
                       header - 1)."
END_OBJECT           = BIT_COLUMN
OBJECT               = BIT_COLUMN
  NAME               = RESERVED1
  COLUMN_NUMBER      = 8
  START_BIT          = 49
  BITS               = 1
  BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
  MINIMUM            = 0
  MAXIMUM            = 0
  DESCRIPTION        = "Reserved (value = 0)."
END_OBJECT           = BIT_COLUMN
OBJECT               = BIT_COLUMN
  NAME               = TIME
  COLUMN_NUMBER      = 9
  START_BIT          = 50
  BITS               = 31
```

```
    BIT_DATA_TYPE       = MSB_UNSIGNED_INTEGER
    UNIT                = SECONDS
    MINIMUM             = 0
    MAXIMUM             = 2147483647
    DESCRIPTION         = "Spacecraft Time in Seconds (seconds elapsed since 1
                          January 2001)."
  END_OBJECT            = BIT_COLUMN
  OBJECT                = BIT_COLUMN
    NAME                = FRACTIME
    COLUMN_NUMBER       = 10
    START_BIT           = 81
    BITS                = 4
    BIT_DATA_TYPE       = MSB_UNSIGNED_INTEGER
    UNIT                = "1/16 SECONDS"
    MINIMUM             = 0
    MAXIMUM             = 15
    DESCRIPTION         = "Spacecraft Time in Fractional Seconds (1/16 second
                          units)."
  END_OBJECT            = BIT_COLUMN
  OBJECT                = BIT_COLUMN
    NAME                = RESERVED2
    COLUMN_NUMBER       = 11
    START_BIT           = 85
    BITS                = 5
    BIT_DATA_TYPE       = MSB_UNSIGNED_INTEGER
    MINIMUM             = 0
    MAXIMUM             = 0
    DESCRIPTION         = "Reserved (value = 0)."
  END_OBJECT            = BIT_COLUMN
  OBJECT                = BIT_COLUMN
    NAME                = TESTFLAG
    COLUMN_NUMBER       = 12
    START_BIT           = 90
    BITS                = 1
    BIT_DATA_TYPE       = MSB_UNSIGNED_INTEGER
    MINIMUM             = 0
    MAXIMUM             = 1
    DESCRIPTION         = "Test Mode Flag (1 = test enabled)."
  END_OBJECT            = BIT_COLUMN
  OBJECT                = BIT_COLUMN
    NAME                = ONEHERTZ
    COLUMN_NUMBER       = 13
    START_BIT           = 91
    BITS                = 1
    BIT_DATA_TYPE       = MSB_UNSIGNED_INTEGER
    MINIMUM             = 0
    MAXIMUM             = 1
    DESCRIPTION         = "External One Hertz time sync pulse (1 = not
                          received)."
  END_OBJECT            = BIT_COLUMN
  OBJECT                = BIT_COLUMN
    NAME                = SERIALNUMBER
    COLUMN_NUMBER       = 14
    START_BIT           = 92
    BITS                = 5
    BIT_DATA_TYPE       = MSB_UNSIGNED_INTEGER
    MINIMUM             = 0
    MAXIMUM             = 31
```

```
  DESCRIPTION          = "Instrument Serial Number."
END_OBJECT             = BIT_COLUMN
```

C.3 Level 0 Primary Science Record (CRAT_L0_PRI.FMT)

```
OBJECT                 = COLUMN
  NAME                 = HEADER
  COLUMN_NUMBER        = 1
  START_BYTE           = 1
  BYTES                = 12
  ^STRUCTURE           = "CRAT_L0_HDR.FMT"
  DATA_TYPE            = BIT_STRING
  DESCRIPTION          = "CCSDS Primary and Secondary Headers, ApId = 120."
END_OBJECT             = COLUMN
OBJECT                 = COLUMN
  NAME                 = EVENT
  COLUMN_NUMBER        = 2
  START_BYTE           = 13
  BYTES                = 432
  ITEM_BYTES           = 9
  ITEMS                = 48
  DATA_TYPE            = BIT_STRING
  DESCRIPTION          = "Array of single particle events expressed as signals
                         recorded by detectors 1..6."
  OBJECT               = BIT_COLUMN
    NAME               = EVENTAMP1
    COLUMN_NUMBER      = 1
    START_BIT          = 1
    BITS               = 12
    BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
    MINIMUM            = 0
    MAXIMUM            = 4095
    DESCRIPTION        = "Signal recorded by detector 1 as a result of a single
                         particle event."
  END_OBJECT           = BIT_COLUMN
  OBJECT               = BIT_COLUMN
    NAME               = EVENTAMP2
    COLUMN_NUMBER      = 2
    START_BIT          = 13
    BITS               = 12
    BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
    MINIMUM            = 0
    MAXIMUM            = 4095
    DESCRIPTION        = "Signal recorded by detector 2 as a result of a single
                         particle event."
  END_OBJECT           = BIT_COLUMN
  OBJECT               = BIT_COLUMN
    NAME               = EVENTAMP3
    COLUMN_NUMBER      = 3
    START_BIT          = 25
    BITS               = 12
    BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
    MINIMUM            = 0
    MAXIMUM            = 4095
    DESCRIPTION        = "Signal recorded by detector 3 as a result of a single
                         particle event."
  END_OBJECT           = BIT_COLUMN
  OBJECT               = BIT_COLUMN
```

```
    NAME              = EVENTAMP4
    COLUMN_NUMBER     = 4
    START_BIT         = 37
    BITS              = 12
    BIT_DATA_TYPE     = MSB_UNSIGNED_INTEGER
    MINIMUM           = 0
    MAXIMUM           = 4095
    DESCRIPTION       = "Signal recorded by detector 4 as a result of a single
                        particle event."
  END_OBJECT          = BIT_COLUMN
  OBJECT              = BIT_COLUMN
    NAME              = EVENTAMP5
    COLUMN_NUMBER     = 5
    START_BIT         = 49
    BITS              = 12
    BIT_DATA_TYPE     = MSB_UNSIGNED_INTEGER
    MINIMUM           = 0
    MAXIMUM           = 4095
    DESCRIPTION       = "Signal recorded by detector 5 as a result of a single
                        particle event."
  END_OBJECT          = BIT_COLUMN
  OBJECT              = BIT_COLUMN
    NAME              = EVENTAMP6
    COLUMN_NUMBER     = 6
    START_BIT         = 61
    BITS              = 12
    BIT_DATA_TYPE     = MSB_UNSIGNED_INTEGER
    MINIMUM           = 0
    MAXIMUM           = 4095
    DESCRIPTION       = "Signal recorded by detector 6 as a result of a single
                        particle event."
  END_OBJECT          = BIT_COLUMN
END_OBJECT            = COLUMN
```

C.4 Level 0 Secondary Science Record (CRAT_L0_SEC.FMT)

```
OBJECT                = COLUMN
  NAME                = HEADER
  COLUMN_NUMBER       = 1
  START_BYTE          = 1
  BYTES               = 12
  ^STRUCTURE          = "CRAT_L0_HDR.FMT"
  DATA_TYPE           = BIT_STRING
  DESCRIPTION         = "CCSDS Primary and Secondary Headers, ApId = 121."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = SECONDARYFLGS
  COLUMN_NUMBER       = 2
  START_BYTE          = 13
  BYTES               = 4
  DATA_TYPE           = BIT_STRING
  DESCRIPTION         = "Secondary Science Flags."
  OBJECT              = BIT_COLUMN
    NAME              = BIASCNTRL
    COLUMN_NUMBER     = 1
    START_BIT         = 1
    BITS              = 1
    BIT_DATA_TYPE     = MSB_UNSIGNED_INTEGER
```

```
    MINIMUM           = 0
    MAXIMUM           = 1
    DESCRIPTION       = "Detector Bias Delayed Control (1 = enabled)."
  END_OBJECT          = BIT_COLUMN
  OBJECT              = BIT_COLUMN
    NAME              = BIASCMD
    COLUMN_NUMBER     = 2
    START_BIT         = 2
    BITS              = 1
    BIT_DATA_TYPE     = MSB_UNSIGNED_INTEGER
    MINIMUM           = 0
    MAXIMUM           = 1
    DESCRIPTION       = "Detector Bias Voltage (1 = on)."
  END_OBJECT          = BIT_COLUMN
  OBJECT              = BIT_COLUMN
    NAME              = CALLOW
    COLUMN_NUMBER     = 3
    START_BIT         = 3
    BITS              = 1
    BIT_DATA_TYPE     = MSB_UNSIGNED_INTEGER
    MINIMUM           = 0
    MAXIMUM           = 1
    DESCRIPTION       = "Electrical Calibration Range Low (1 = enabled)."
  END_OBJECT          = BIT_COLUMN
  OBJECT              = BIT_COLUMN
    NAME              = CALHIGH
    COLUMN_NUMBER     = 4
    START_BIT         = 4
    BITS              = 1
    BIT_DATA_TYPE     = MSB_UNSIGNED_INTEGER
    MINIMUM           = 0
    MAXIMUM           = 1
    DESCRIPTION       = "Electrical Calibration Range High (1 = enabled)."
  END_OBJECT          = BIT_COLUMN
  OBJECT              = BIT_COLUMN
    NAME              = CALRATE
    COLUMN_NUMBER     = 5
    START_BIT         = 5
    BITS              = 1
    BIT_DATA_TYPE     = MSB_UNSIGNED_INTEGER
    MINIMUM           = 0
    MAXIMUM           = 1
    DESCRIPTION       = "Electrical Calibration Rate (1 = 1953 events/sec; 0 =
                        8 events/sec)."
  END_OBJECT          = BIT_COLUMN
  OBJECT              = BIT_COLUMN
    NAME              = PROCDFLAG
    COLUMN_NUMBER     = 6
    START_BIT         = 6
    BITS              = 6
    ITEM_BITS         = 1
    ITEMS             = 6
    BIT_DATA_TYPE     = MSB_UNSIGNED_INTEGER
    MINIMUM           = 0
    MAXIMUM           = 1
    DESCRIPTION       = "Detector Processing Enabled (1 = enabled)."
  END_OBJECT          = BIT_COLUMN
  OBJECT              = BIT_COLUMN
```

```
    NAME               = LASTCMD
    COLUMN_NUMBER      = 7
    START_BIT          = 12
    BITS               = 5
    BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
    MINIMUM            = 0
    MAXIMUM            = 31
    DESCRIPTION        = "Address of Last Command to CRaTER."
  END_OBJECT           = BIT_COLUMN
  OBJECT               = BIT_COLUMN
    NAME               = LASTVALUE
    COLUMN_NUMBER      = 8
    START_BIT          = 17
    BITS               = 16
    BIT_DATA_TYPE      = MSB_UNSIGNED_INTEGER
    MINIMUM            = 0
    MAXIMUM            = 65535
    DESCRIPTION        = "Contents of Last Command to CRaTER."
  END_OBJECT           = BIT_COLUMN
END_OBJECT             = COLUMN
OBJECT                 = COLUMN
  NAME                 = DISCTHIN
  COLUMN_NUMBER        = 3
  START_BYTE           = 17
  BYTES                = 2
  DATA_TYPE            = MSB_UNSIGNED_INTEGER
  MINIMUM              = 0
  MAXIMUM              = 65535
  DESCRIPTION          = "Low Level Discriminator Setting for Thin Detectors
                         (D1, D3, D5)."
END_OBJECT             = COLUMN
OBJECT                 = COLUMN
  NAME                 = DISCTHICK
  COLUMN_NUMBER        = 4
  START_BYTE           = 19
  BYTES                = 2
  DATA_TYPE            = MSB_UNSIGNED_INTEGER
  MINIMUM              = 0
  MAXIMUM              = 65535
  DESCRIPTION          = "Low Level Discriminator Setting for Thick Detectors
                         (D2, D4, D6)."
END_OBJECT             = COLUMN
OBJECT                 = COLUMN
  NAME                 = MASK
  COLUMN_NUMBER        = 5
  START_BYTE           = 21
  BYTES                = 8
  ITEM_BYTES           = 4
  ITEMS                = 2
  DATA_TYPE            = MSB_UNSIGNED_INTEGER
  MINIMUM              = 0
  MAXIMUM              = 65535
  DESCRIPTION          = "Discriminator Accept Mask (64 bits)."
END_OBJECT             = COLUMN
OBJECT                 = COLUMN
  NAME                 = SINGLE
  COLUMN_NUMBER        = 6
  START_BYTE           = 29
```

```
  BYTES               = 12
  ITEM_BYTES          = 2
  ITEMS               = 6
  DATA_TYPE           = MSB_UNSIGNED_INTEGER
  MINIMUM             = 0
  MAXIMUM             = 65535
  DESCRIPTION         = "Detector Singles Counter (one for each of 6
                        detectors)."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = GOOD
  COLUMN_NUMBER       = 7
  START_BYTE          = 41
  BYTES               = 2
  DATA_TYPE           = MSB_UNSIGNED_INTEGER
  MINIMUM             = 0
  MAXIMUM             = 65535
  DESCRIPTION         = "Good Events Counter."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = REJECT
  COLUMN_NUMBER       = 8
  START_BYTE          = 43
  BYTES               = 2
  DATA_TYPE           = MSB_UNSIGNED_INTEGER
  MINIMUM             = 0
  MAXIMUM             = 65535
  DESCRIPTION         = "Rejected Events Counter."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = TOTAL
  COLUMN_NUMBER       = 9
  START_BYTE          = 45
  BYTES               = 2
  DATA_TYPE           = MSB_UNSIGNED_INTEGER
  MINIMUM             = 0
  MAXIMUM             = 65535
  DESCRIPTION         = "Total Events Counter."
END_OBJECT            = COLUMN
```

C.5 Level 0 Housekeeping Record (CRAT_L0_HK.FMT)

```
OBJECT                = COLUMN
  NAME                = HEADER
  COLUMN_NUMBER       = 1
  START_BYTE          = 1
  BYTES               = 12
  ^STRUCTURE          = "CRAT_L0_HDR.FMT"
  DATA_TYPE           = BIT_STRING
  DESCRIPTION         = "CCSDS Primary and Secondary Headers, ApId = 122."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = CRATV28BUS
  COLUMN_NUMBER       = 2
  START_BYTE          = 13
  BYTES               = 2
  DATA_TYPE           = BIT_STRING
  DESCRIPTION         = "FPGA revision code and 28VDC bus voltage."
```

```
    OBJECT              = BIT_COLUMN
      NAME              = FPGA_SN
      COLUMN_NUMBER     = 1
      START_BIT         = 1
      BITS              = 4
      BIT_DATA_TYPE     = MSB_UNSIGNED_INTEGER
      MINIMUM           = 0
      MAXIMUM           = 15
      DESCRIPTION       = "FPGA revision code."
    END_OBJECT          = BIT_COLUMN
    OBJECT              = BIT_COLUMN
      NAME              = V28BUS
      COLUMN_NUMBER     = 2
      START_BIT         = 5
      BITS              = 12
      BIT_DATA_TYPE     = MSB_UNSIGNED_INTEGER
      UNIT              = "VOLTS = 0.00101*DN"
      MINIMUM           = 0
      MAXIMUM           = 4095
      DESCRIPTION       = "Spacecraft 28VDC bus voltage."
    END_OBJECT          = BIT_COLUMN
  END_OBJECT            = COLUMN
  OBJECT                = COLUMN
    NAME                = V5DIGITAL
    COLUMN_NUMBER       = 3
    START_BYTE          = 15
    BYTES               = 2
    DATA_TYPE           = MSB_UNSIGNED_INTEGER
    UNIT                = "VOLTS = 0.00200*DN"
    MINIMUM             = 0
    MAXIMUM             = 4095
    DESCRIPTION         = "+5VDC digital regulated voltage."
  END_OBJECT            = COLUMN
  OBJECT                = COLUMN
    NAME                = CRATV5PLUS
    COLUMN_NUMBER       = 4
    START_BYTE          = 17
    BYTES               = 2
    DATA_TYPE           = BIT_STRING
    DESCRIPTION         = "Analog voltage indicator and -5VDC analog regulated
                          voltage."
    OBJECT              = BIT_COLUMN
      NAME              = VANALOGERR
      COLUMN_NUMBER     = 1
      START_BIT         = 1
      BITS              = 4
      BIT_DATA_TYPE     = MSB_UNSIGNED_INTEGER
      MINIMUM           = 0
      MAXIMUM           = 15
      DESCRIPTION       = "Analog voltage indicator (0: on; 15: off, so
                          remaining H/K is invalid)."
    END_OBJECT          = BIT_COLUMN
    OBJECT              = BIT_COLUMN
      NAME              = V5PLUS
      COLUMN_NUMBER     = 2
      START_BIT         = 5
      BITS              = 12
      BIT_DATA_TYPE     = MSB_UNSIGNED_INTEGER
```

```
    UNIT              = "VOLTS = 0.00200*DN"
    MINIMUM           = 0
    MAXIMUM           = 4095
    DESCRIPTION       = "+5VDC analog regulated voltage."
  END_OBJECT          = BIT_COLUMN
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = V5NEG
  COLUMN_NUMBER       = 5
  START_BYTE          = 19
  BYTES               = 2
  DATA_TYPE           = MSB_UNSIGNED_INTEGER
  UNIT                = "VOLTS = -0.00201*DN"
  MINIMUM             = 0
  MAXIMUM             = 4095
  DESCRIPTION         = "-5VDC analog regulated voltage."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = I28BUS
  COLUMN_NUMBER       = 6
  START_BYTE          = 21
  BYTES               = 2
  DATA_TYPE           = MSB_UNSIGNED_INTEGER
  UNIT                = "AMPS = 0.000198*DN"
  MINIMUM             = 0
  MAXIMUM             = 4095
  DESCRIPTION         = "Instrument current drain off spacecraft bus."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = BIASCURRENT
  COLUMN_NUMBER       = 7
  START_BYTE          = 23
  BYTES               = 12
  ITEM_BYTES          = 2
  ITEMS               = 6
  DATA_TYPE           = MSB_UNSIGNED_INTEGER
  UNIT                = "AMPS = 5E-10*DN, 5E-9*DN, 5E-10*DN, ..."
  MINIMUM             = 0
  MAXIMUM             = 4095
  DESCRIPTION         = "Detector bias current."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = BIASVOLTTHIN
  COLUMN_NUMBER       = 8
  START_BYTE          = 35
  BYTES               = 2
  DATA_TYPE           = MSB_UNSIGNED_INTEGER
  UNIT                = "VOLTS = 0.101*DN"
  MINIMUM             = 0
  MAXIMUM             = 4095
  DESCRIPTION         = "Thin detector (D1, D3, D5) bias voltage."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = BIASVOLTTHICK
  COLUMN_NUMBER       = 9
  START_BYTE          = 37
  BYTES               = 2
  DATA_TYPE           = MSB_UNSIGNED_INTEGER
```

```
  UNIT                = "VOLTS = 0.101*DN"
  MINIMUM             = 0
  MAXIMUM             = 4095
  DESCRIPTION         = "Thick detector (D2, D4, D6) bias voltage."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = CALAMP
  COLUMN_NUMBER       = 10
  START_BYTE          = 39
  BYTES               = 2
  DATA_TYPE           = MSB_UNSIGNED_INTEGER
  UNIT                = "VOLTS = 0.00100*DN"
  MINIMUM             = 0
  MAXIMUM             = 4095
  DESCRIPTION         = "Electrical calibration voltage amplitude."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = LLDTHIN
  COLUMN_NUMBER       = 11
  START_BYTE          = 41
  BYTES               = 2
  DATA_TYPE           = MSB_UNSIGNED_INTEGER
  UNIT                = "VOLTS = 0.000124*DN - 0.124"
  MINIMUM             = 0
  MAXIMUM             = 4095
  DESCRIPTION         = "Low Level Discriminator voltage for thin detectors
                        (D1, D3, D5)."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = LLDTHICK
  COLUMN_NUMBER       = 12
  START_BYTE          = 43
  BYTES               = 2
  DATA_TYPE           = MSB_UNSIGNED_INTEGER
  UNIT                = "VOLTS = 0.000124*DN - 0.124"
  MINIMUM             = 0
  MAXIMUM             = 4095
  DESCRIPTION         = "Low Level Discriminator voltage for thick detectors
                        (D2, D4, D6)."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = TTELESCOPE
  COLUMN_NUMBER       = 13
  START_BYTE          = 45
  BYTES               = 2
  DATA_TYPE           = MSB_UNSIGNED_INTEGER
  UNIT                = "CELSIUS = 100*V5plus - 0.100*DN - 273.2"
  MINIMUM             = 0
  MAXIMUM             = 4095
  DESCRIPTION         = "Temperature of telescope assembly (in UNITS formula,
                        V5plus is expressed in volts)."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = TANALOG
  COLUMN_NUMBER       = 14
  START_BYTE          = 47
  BYTES               = 2
  DATA_TYPE           = MSB_UNSIGNED_INTEGER
```

```
  UNIT                = "CELSIUS = 100*V5plus - 0.100*DN - 273.2"
  MINIMUM             = 0
  MAXIMUM             = 4095
  DESCRIPTION         = "Temperature of analog electronics (in UNITS formula,
                        V5plus is expressed in volts)."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = TDIGITAL
  COLUMN_NUMBER       = 15
  START_BYTE          = 49
  BYTES               = 2
  DATA_TYPE           = MSB_UNSIGNED_INTEGER
  UNIT                = "CELSIUS = 100*V5plus - 0.100*DN - 273.2"
  MINIMUM             = 0
  MAXIMUM             = 4095
  DESCRIPTION         = "Temperature of digital electronics (in UNITS formula,
                        V5plus is expressed in volts)."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = TPOWER
  COLUMN_NUMBER       = 16
  START_BYTE          = 51
  BYTES               = 2
  DATA_TYPE           = MSB_UNSIGNED_INTEGER
  UNIT                = "CELSIUS = 100*V5plus - 0.100*DN - 273.2"
  MINIMUM             = 0
  MAXIMUM             = 4095
  DESCRIPTION         = "Temperature of regulate power supply (in UNITS
                        formula, V5plus is expressed in volts)."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = TREF
  COLUMN_NUMBER       = 17
  START_BYTE          = 53
  BYTES               = 2
  DATA_TYPE           = MSB_UNSIGNED_INTEGER
  UNIT                = "CELSIUS = 100*V5plus - 0.100*DN - 273.2"
  MINIMUM             = 0
  MAXIMUM             = 4095
  DESCRIPTION         = "Temperature of reference location on telescope wall
                        (in UNITS formula, V5plus is expressed in volts)."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = RADHIGHSENS
  COLUMN_NUMBER       = 18
  START_BYTE          = 55
  BYTES               = 2
  DATA_TYPE           = MSB_UNSIGNED_INTEGER
  UNIT                = "RADS = 0.00002*((DN+8)/16)"
  MINIMUM             = 0
  MAXIMUM             = 4095
  DESCRIPTION         = "High Sensitivity Radiation monitor voltage."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = RADMEDSENS
  COLUMN_NUMBER       = 19
  START_BYTE          = 57
  BYTES               = 2
```

```
  DATA_TYPE           = MSB_UNSIGNED_INTEGER
  UNIT                = "RADS = 0.00512*((DN+8)/16)"
  MINIMUM             = 0
  MAXIMUM             = 4095
  DESCRIPTION         = "Medium Sensitivity Radiation monitor voltage."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = RADLOWSENS
  COLUMN_NUMBER       = 20
  START_BYTE          = 59
  BYTES               = 2
  DATA_TYPE           = MSB_UNSIGNED_INTEGER
  UNIT                = "RADS = 1.31*((DN+8)/16)"
  MINIMUM             = 0
  MAXIMUM             = 4095
  DESCRIPTION         = "Low Sensitivity Radiation monitor voltage."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = TPRT
  COLUMN_NUMBER       = 21
  START_BYTE          = 61
  BYTES               = 2
  DATA_TYPE           = MSB_UNSIGNED_INTEGER
  UNIT                = "CELSIUS = 0.1299*(4*DN-1E4)/(5-DN/1E3)"
  MINIMUM             = 0
  MAXIMUM             = 4095
  DESCRIPTION         = "Temperature of reference location on instrument
                        chassis (ground test only)."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = PURGE
  COLUMN_NUMBER       = 22
  START_BYTE          = 63
  BYTES               = 2
  DATA_TYPE           = MSB_UNSIGNED_INTEGER
  UNIT                = "CU FT/HR = DN-0.371*V5plus+19*(Tref-20)"
  MINIMUM             = 0
  MAXIMUM             = 4095
  DESCRIPTION         = "Flow rate of GN2 purge  (ground test only; in UNITS
                        formula, V5plus and Tref are expressed in volts and
                        celsius)."
END_OBJECT            = COLUMN
```

Appendix D Level 1 data record formats

This section shows the contents of the FMT files for each of the three types of Level 1 data.

D.1 Level 1 Primary Science Record (CRAT_L1_PRI.FMT)

```
OBJECT                 = COLUMN
  NAME                 = SECONDS
  COLUMN_NUMBER        = 1
  START_BYTE           = 1
  BYTES                = 9
  DATA_TYPE            = ASCII_INTEGER
  FORMAT               = I9
  UNIT                 = SECONDS
  DESCRIPTION          = "Elapsed time from 0h UT Jan 1 2001 to 1 Hz pulse."
END_OBJECT             = COLUMN
OBJECT                 = COLUMN
  NAME                 = FRACT
  COLUMN_NUMBER        = 2
  START_BYTE           = 11
  BYTES                = 2
  DATA_TYPE            = ASCII_INTEGER
  FORMAT               = I2
  UNIT                 = "1/100 SECOND"
  DESCRIPTION          = "Hundredths of a second from 1 Hz pulse."
END_OBJECT             = COLUMN
OBJECT                 = COLUMN
  NAME                 = INDEX
  COLUMN_NUMBER        = 3
  START_BYTE           = 14
  BYTES                = 6
  DATA_TYPE            = ASCII_INTEGER
  FORMAT               = I6
  UNIT                 = "N/A"
  DESCRIPTION          = "Index of event within the current second."
END_OBJECT             = COLUMN
OBJECT                 = COLUMN
  NAME                 = AMPL
  COLUMN_NUMBER        = 4
  START_BYTE           = 21
  BYTES                = 29
  ITEM_BYTES           = 4
  ITEM_OFFSET          = 5
  ITEMS                = 6
  DATA_TYPE            = ASCII_INTEGER
  FORMAT               = I4
  UNIT                 = "N/A"
  DESCRIPTION          = "Amplitude in Detectors 1 to 6."
END_OBJECT             = COLUMN
OBJECT                 = COLUMN
  NAME                 = ENERGY
  COLUMN_NUMBER        = 5
  START_BYTE           = 51
  BYTES                = 65
  ITEM_BYTES           = 10
  ITEM_OFFSET          = 11
  ITEMS                = 6
  DATA_TYPE            = ASCII_REAL
```

```
  FORMAT              = "E10.4"
  UNIT                = "ELECTRON VOLTS"
  DESCRIPTION         = "Energy deposited in Detectors 1 to 6."
END_OBJECT            = COLUMN
```

D.2 Level 1 Secondary Science Record (CRAT_L1_SEC.FMT)

```
OBJECT                = COLUMN
  NAME                = SECONDS
  COLUMN_NUMBER       = 1
  START_BYTE          = 1
  BYTES               = 9
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I9
  UNIT                = SECONDS
  DESCRIPTION         = "Elapsed time from 0h UT Jan 1 2001 to timing pulse."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = FRACT
  COLUMN_NUMBER       = 2
  START_BYTE          = 11
  BYTES               = 2
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I2
  UNIT                = "1/100 SECOND"
  DESCRIPTION         = "Hundredths of a second from 1 Hz pulse."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = BIASCNTRL
  COLUMN_NUMBER       = 3
  START_BYTE          = 14
  BYTES               = 1
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I1
  UNIT                = "N/A"
  DESCRIPTION         = "Detector Bias Delayed Control (1 = enabled)."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = BIASCMD
  COLUMN_NUMBER       = 4
  START_BYTE          = 16
  BYTES               = 1
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I1
  UNIT                = "N/A"
  DESCRIPTION         = "Detector Bias Voltage (1 = on)."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = CALLOW
  COLUMN_NUMBER       = 5
  START_BYTE          = 18
  BYTES               = 1
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I1
  UNIT                = "N/A"
  DESCRIPTION         = "Electrical Calibration Range Low (1 = enabled)."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
```

```
  NAME                = CALHIGH
  COLUMN_NUMBER       = 6
  START_BYTE          = 20
  BYTES               = 1
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I1
  UNIT                = "N/A"
  DESCRIPTION         = "Electrical Calibration Range High (1 = enabled)."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = CALRATE
  COLUMN_NUMBER       = 7
  START_BYTE          = 22
  BYTES               = 1
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I1
  UNIT                = "N/A"
  DESCRIPTION         = "Electrical Calibration Rate (1 = 1953 /sec; 0 = 8
                        /sec)."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = PROCDFLAG
  COLUMN_NUMBER       = 8
  START_BYTE          = 24
  BYTES               = 11
  ITEM_BYTES          = 1
  ITEM_OFFSET         = 2
  ITEMS               = 6
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I1
  UNIT                = "N/A"
  DESCRIPTION         = "Detector Processing Enabled (1 = enabled)."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = LASTCMD
  COLUMN_NUMBER       = 9
  START_BYTE          = 36
  BYTES               = 5
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I5
  UNIT                = "N/A"
  DESCRIPTION         = "Address of Last Command."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = LASTVALUE
  COLUMN_NUMBER       = 10
  START_BYTE          = 42
  BYTES               = 5
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I5
  UNIT                = "N/A"
  DESCRIPTION         = "Contents of Last Command."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = DISCTHIN
  COLUMN_NUMBER       = 11
  START_BYTE          = 48
  BYTES               = 5
```

```
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I5
  UNIT                = "N/A"
  DESCRIPTION         = "Event Amplitude Discriminator Settings (D1,3,5)."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = DISCTHICK
  COLUMN_NUMBER       = 12
  START_BYTE          = 54
  BYTES               = 5
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I5
  UNIT                = "N/A"
  DESCRIPTION         = "Event Amplitude Discriminator Settings (D2,4,6)."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = MASK
  COLUMN_NUMBER       = 13
  START_BYTE          = 60
  BYTES               = 21
  ITEM_BYTES          = 10
  ITEM_OFFSET         = 11
  ITEMS               = 2
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I10
  UNIT                = "N/A"
  DESCRIPTION         = "Discriminator Accept Mask (64 bits)."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = SINGLE
  COLUMN_NUMBER       = 14
  START_BYTE          = 82
  BYTES               = 35
  ITEM_BYTES          = 5
  ITEM_OFFSET         = 6
  ITEMS               = 6
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I5
  UNIT                = "N/A"
  DESCRIPTION         = "Detector Singles Counters 1 to 6."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = GOOD
  COLUMN_NUMBER       = 15
  START_BYTE          = 118
  BYTES               = 5
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I5
  UNIT                = "N/A"
  DESCRIPTION         = "Good Event Counter."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = REJECT
  COLUMN_NUMBER       = 16
  START_BYTE          = 124
  BYTES               = 5
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I5
```

```
  UNIT                = "N/A"
  DESCRIPTION         = "Event Reject Counter."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = TOTAL
  COLUMN_NUMBER       = 17
  START_BYTE          = 130
  BYTES               = 5
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I5
  UNIT                = "N/A"
  DESCRIPTION         = "Total Event Counter."
END_OBJECT            = COLUMN
```

D.3 Level 1 Housekeeping Record (CRAT_L1_HK.FMT)

```
OBJECT                = COLUMN
  NAME                = SECONDS
  COLUMN_NUMBER       = 1
  START_BYTE          = 1
  BYTES               = 9
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I9
  UNIT                = SECONDS
  DESCRIPTION         = "Elapsed time from 0h UT Jan 1 2001 to timing pulse."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = FRACT
  COLUMN_NUMBER       = 2
  START_BYTE          = 11
  BYTES               = 2
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I2
  UNIT                = "1/100 SECOND"
  DESCRIPTION         = "Hundredths of a second from 1 Hz pulse."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = FPGA_SN
  COLUMN_NUMBER       = 3
  START_BYTE          = 14
  BYTES               = 2
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I2
  UNIT                = "N/A"
  DESCRIPTION         = "FPGA Revision Code."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = V28BUS
  COLUMN_NUMBER       = 4
  START_BYTE          = 17
  BYTES               = 7
  DATA_TYPE           = ASCII_REAL
  FORMAT              = "F7.3"
  UNIT                = VOLTS
  DESCRIPTION         = "28VDC Monitor."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = V5DIGITAL
```

```
  COLUMN_NUMBER      = 5
  START_BYTE         = 25
  BYTES              = 7
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "F7.3"
  UNIT               = VOLTS
  DESCRIPTION        = "+5VDC Digital Monitor."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = VANALOGERR
  COLUMN_NUMBER      = 6
  START_BYTE         = 33
  BYTES              = 2
  DATA_TYPE          = ASCII_INTEGER
  FORMAT             = I2
  UNIT               = "N/A"
  DESCRIPTION        = "Analog Voltage Indicator (0: on; 15: off, so H/K is
                       invalid)."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = V5PLUS
  COLUMN_NUMBER      = 7
  START_BYTE         = 36
  BYTES              = 7
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "F7.3"
  UNIT               = VOLTS
  DESCRIPTION        = "+5VDC Analog Monitor."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = V5NEG
  COLUMN_NUMBER      = 8
  START_BYTE         = 44
  BYTES              = 7
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "F7.3"
  UNIT               = VOLTS
  DESCRIPTION        = "-5VDC Analog Monitor."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = I28BUS
  COLUMN_NUMBER      = 9
  START_BYTE         = 52
  BYTES              = 7
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "F7.3"
  UNIT               = VOLTS
  DESCRIPTION        = "+2.5VDC Internal Reference."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = P28BUS
  COLUMN_NUMBER      = 10
  START_BYTE         = 60
  BYTES              = 7
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "F7.3"
  UNIT               = WATTS
  DESCRIPTION        = "Instrument power (V28bus*I28bus)."
```

```
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = BIASCURRENT
  COLUMN_NUMBER     = 11
  START_BYTE        = 68
  BYTES             = 47
  ITEM_BYTES        = 7
  ITEM_OFFSET       = 8
  ITEMS             = 6
  DATA_TYPE         = ASCII_REAL
  FORMAT            = "F7.3"
  UNIT              = AMPS
  DESCRIPTION       = "Detector Bias Current Monitors."
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = BIASVOLTTHIN
  COLUMN_NUMBER     = 12
  START_BYTE        = 116
  BYTES             = 7
  DATA_TYPE         = ASCII_REAL
  FORMAT            = "F7.3"
  UNIT              = VOLTS
  DESCRIPTION       = "Thin Detector Bias Voltage Monitor."
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = BIASVOLTTHICK
  COLUMN_NUMBER     = 13
  START_BYTE        = 124
  BYTES             = 7
  DATA_TYPE         = ASCII_REAL
  FORMAT            = "F7.3"
  UNIT              = VOLTS
  DESCRIPTION       = "Thick Detector Bias Voltage Monitor."
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = CALAMP
  COLUMN_NUMBER     = 14
  START_BYTE        = 132
  BYTES             = 7
  DATA_TYPE         = ASCII_REAL
  FORMAT            = "F7.3"
  UNIT              = VOLTS
  DESCRIPTION       = "Electrical Calibration Amplitude Monitor."
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = LLDTHIN
  COLUMN_NUMBER     = 15
  START_BYTE        = 140
  BYTES             = 7
  DATA_TYPE         = ASCII_REAL
  FORMAT            = "F7.3"
  UNIT              = VOLTS
  DESCRIPTION       = "Thin Detector LLD Voltage Monitor."
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = LLDTHICK
  COLUMN_NUMBER     = 16
  START_BYTE        = 148
```

```
  BYTES              = 7
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "F7.3"
  UNIT               = VOLTS
  DESCRIPTION        = "Thick Detector LLD Voltage Monitor."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = TTELESCOPE
  COLUMN_NUMBER      = 17
  START_BYTE         = 156
  BYTES              = 7
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "F7.2"
  UNIT               = CELSIUS
  DESCRIPTION        = "Telescope Temperature."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = TANALOG
  COLUMN_NUMBER      = 18
  START_BYTE         = 164
  BYTES              = 7
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "F7.2"
  UNIT               = CELSIUS
  DESCRIPTION        = "Analog Board Temperature."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = TDIGITAL
  COLUMN_NUMBER      = 19
  START_BYTE         = 172
  BYTES              = 7
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "F7.2"
  UNIT               = CELSIUS
  DESCRIPTION        = "Digital Board Temperature."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = TPOWER
  COLUMN_NUMBER      = 20
  START_BYTE         = 180
  BYTES              = 7
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "F7.2"
  UNIT               = CELSIUS
  DESCRIPTION        = "Power Supply Temperature."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = TREF
  COLUMN_NUMBER      = 21
  START_BYTE         = 188
  BYTES              = 7
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "F7.2"
  UNIT               = CELSIUS
  DESCRIPTION        = "Bulkhead Reference Temperature."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = RADHIGHSENS
```

```
  COLUMN_NUMBER      = 22
  START_BYTE         = 196
  BYTES              = 10
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "E10.4"
  UNIT               = RADS
  DESCRIPTION        = "High Sensitivity Radiation monitor voltage."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = RADMEDSENS
  COLUMN_NUMBER      = 23
  START_BYTE         = 207
  BYTES              = 10
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "E10.4"
  UNIT               = RADS
  DESCRIPTION        = "Medium Sensitivity Radiation monitor voltage."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = RADLOWSENS
  COLUMN_NUMBER      = 24
  START_BYTE         = 218
  BYTES              = 10
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "E10.4"
  UNIT               = RADS
  DESCRIPTION        = "Low Sensitivity Radiation monitor voltage."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = TPRT
  COLUMN_NUMBER      = 25
  START_BYTE         = 229
  BYTES              = 10
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "E10.4"
  UNIT               = CELSIUS
  DESCRIPTION        = "PRT Reference (Ground Test Only)."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = PURGE
  COLUMN_NUMBER      = 26
  START_BYTE         = 240
  BYTES              = 10
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "E10.4"
  UNIT               = "CUBIC FEET PER HOUR"
  DESCRIPTION        = "Purge Flow Rate (Ground Test Only)."
END_OBJECT           = COLUMN
```

Appendix E Level 2 data record formats

This section shows the contents of the FMT files for each of the three types of Level 2 data.

E.1 Level 2 Primary Science Record (CRAT_L2_PRI.FMT)

```
OBJECT                  = COLUMN
  NAME                  = SECONDS
  COLUMN_NUMBER         = 1
  START_BYTE            = 1
  BYTES                 = 9
  DATA_TYPE             = ASCII_INTEGER
  FORMAT                = I9
  UNIT                  = SECONDS
  DESCRIPTION           = "Elapsed time from 0h UT Jan 1 2001 to timing pulse."
END_OBJECT              = COLUMN
OBJECT                  = COLUMN
  NAME                  = FRACT
  COLUMN_NUMBER         = 2
  START_BYTE            = 11
  BYTES                 = 2
  DATA_TYPE             = ASCII_INTEGER
  FORMAT                = I2
  UNIT                  = "1/100 SECOND"
  DESCRIPTION           = "Hundredths of a second from 1 Hz pulse."
END_OBJECT              = COLUMN
OBJECT                  = COLUMN
  NAME                  = TIME
  COLUMN_NUMBER         = 3
  START_BYTE            = 15
  BYTES                 = 19
  DATA_TYPE             = TIME
  FORMAT                = A19
  UNIT                  = "N/A"
  DESCRIPTION           = "1 Hz Timing Pulse time in UTC."
END_OBJECT              = COLUMN
OBJECT                  = COLUMN
  NAME                  = INDEX
  COLUMN_NUMBER         = 4
  START_BYTE            = 36
  BYTES                 = 6
  DATA_TYPE             = ASCII_INTEGER
  FORMAT                = I6
  UNIT                  = "N/A"
  DESCRIPTION           = "Index of event within the current second."
END_OBJECT              = COLUMN
OBJECT                  = COLUMN
  NAME                  = AMPL
  COLUMN_NUMBER         = 5
  START_BYTE            = 43
  BYTES                 = 29
  ITEM_BYTES            = 4
  ITEM_OFFSET           = 5
  ITEMS                 = 6
  DATA_TYPE             = ASCII_INTEGER
  FORMAT                = I4
  UNIT                  = "N/A"
  DESCRIPTION           = "Amplitude in Detectors 1 to 6."
```

```
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = ENERGY
  COLUMN_NUMBER      = 6
  START_BYTE         = 73
  BYTES              = 65
  ITEM_BYTES         = 10
  ITEM_OFFSET        = 11
  ITEMS              = 6
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "E10.4"
  UNIT               = "ELECTRON VOLTS"
  DESCRIPTION        = "Energy deposited in Detectors 1 to 6."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = LET
  COLUMN_NUMBER      = 7
  START_BYTE         = 139
  BYTES              = 65
  ITEM_BYTES         = 10
  ITEM_OFFSET        = 11
  ITEMS              = 6
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "E10.4"
  UNIT               = "ELECTRON VOLTS PER MICRON"
  DESCRIPTION        = "Lineal energy transfer in silicon in Detectors 1 to
                       6."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = DQI
  COLUMN_NUMBER      = 8
  START_BYTE         = 205
  BYTES              = 10
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "E10.4"
  UNIT               = "N/A"
  DESCRIPTION        = "Data quality indicator."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = FLAGS
  COLUMN_NUMBER      = 9
  START_BYTE         = 216
  BYTES              = 63
  ITEM_BYTES         = 1
  ITEM_OFFSET        = 2
  ITEMS              = 32
  DATA_TYPE          = ASCII_INTEGER
  FORMAT             = I1
  UNIT               = "N/A"
  DESCRIPTION        = "Flag fields."
END_OBJECT           = COLUMN
```

E.2 Level 2 Secondary Science Record (CRAT_L2_SEC.FMT)

```
OBJECT               = COLUMN
  NAME               = SECONDS
  COLUMN_NUMBER      = 1
  START_BYTE         = 1
  BYTES              = 9
```

```
  DATA_TYPE          = ASCII_INTEGER
  FORMAT             = I9
  UNIT               = SECONDS
  DESCRIPTION        = "Elapsed time from 0h UT Jan 1 2001 to timing pulse."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = FRACT
  COLUMN_NUMBER      = 2
  START_BYTE         = 11
  BYTES              = 2
  DATA_TYPE          = ASCII_INTEGER
  FORMAT             = I2
  UNIT               = "1/100 SECOND"
  DESCRIPTION        = "Hundredths of a second from 1 Hz pulse."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = TIME
  COLUMN_NUMBER      = 3
  START_BYTE         = 15
  BYTES              = 19
  DATA_TYPE          = TIME
  FORMAT             = A19
  UNIT               = "N/A"
  DESCRIPTION        = "1 Hz Timing Pulse time in UTC."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = BIASCNTRL
  COLUMN_NUMBER      = 4
  START_BYTE         = 36
  BYTES              = 1
  DATA_TYPE          = ASCII_INTEGER
  FORMAT             = I1
  UNIT               = "N/A"
  DESCRIPTION        = "Detector Bias Delayed Control (1 = enabled)."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = BIASCMD
  COLUMN_NUMBER      = 5
  START_BYTE         = 38
  BYTES              = 1
  DATA_TYPE          = ASCII_INTEGER
  FORMAT             = I1
  UNIT               = "N/A"
  DESCRIPTION        = "Detector Bias Voltage (1 = on)."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = CALLOW
  COLUMN_NUMBER      = 6
  START_BYTE         = 40
  BYTES              = 1
  DATA_TYPE          = ASCII_INTEGER
  FORMAT             = I1
  UNIT               = "N/A"
  DESCRIPTION        = "Electrical Calibration Range Low (1 = enabled)."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = CALHIGH
  COLUMN_NUMBER      = 7
```

```
  START_BYTE          = 42
  BYTES               = 1
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I1
  UNIT                = "N/A"
  DESCRIPTION         = "Electrical Calibration Range High (1 = enabled)."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = CALRATE
  COLUMN_NUMBER       = 8
  START_BYTE          = 44
  BYTES               = 1
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I1
  UNIT                = "N/A"
  DESCRIPTION         = "Electrical Calibration Rate (1 = 1953 /sec; 0 = 8
                        /sec)."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = PROCDFLAG
  COLUMN_NUMBER       = 9
  START_BYTE          = 46
  BYTES               = 11
  ITEM_BYTES          = 1
  ITEM_OFFSET         = 2
  ITEMS               = 6
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I1
  UNIT                = "N/A"
  DESCRIPTION         = "Detector Processing Enabled (1 = enabled)."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = LASTCMD
  COLUMN_NUMBER       = 10
  START_BYTE          = 58
  BYTES               = 5
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I5
  UNIT                = "N/A"
  DESCRIPTION         = "Address of Last Command."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = LASTVALUE
  COLUMN_NUMBER       = 11
  START_BYTE          = 64
  BYTES               = 5
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I5
  UNIT                = "N/A"
  DESCRIPTION         = "Contents of Last Command."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = DISCTHIN
  COLUMN_NUMBER       = 12
  START_BYTE          = 70
  BYTES               = 5
  DATA_TYPE           = ASCII_INTEGER
  FORMAT              = I5
```

```
  UNIT                 = "N/A"
  DESCRIPTION          = "Event Amplitude Discriminator Settings (D1,3,5)."
END_OBJECT             = COLUMN
OBJECT                 = COLUMN
  NAME                 = DISCTHICK
  COLUMN_NUMBER        = 13
  START_BYTE           = 76
  BYTES                = 5
  DATA_TYPE            = ASCII_INTEGER
  FORMAT               = I5
  UNIT                 = "N/A"
  DESCRIPTION          = "Event Amplitude Discriminator Settings (D2,4,6)."
END_OBJECT             = COLUMN
OBJECT                 = COLUMN
  NAME                 = MASK
  COLUMN_NUMBER        = 14
  START_BYTE           = 82
  BYTES                = 21
  ITEM_BYTES           = 10
  ITEM_OFFSET          = 11
  ITEMS                = 2
  DATA_TYPE            = ASCII_INTEGER
  FORMAT               = I10
  UNIT                 = "N/A"
  DESCRIPTION          = "Discriminator Accept Mask (64 bits)."
END_OBJECT             = COLUMN
OBJECT                 = COLUMN
  NAME                 = SINGLE
  COLUMN_NUMBER        = 15
  START_BYTE           = 104
  BYTES                = 35
  ITEM_BYTES           = 5
  ITEM_OFFSET          = 6
  ITEMS                = 6
  DATA_TYPE            = ASCII_INTEGER
  FORMAT               = I5
  UNIT                 = "N/A"
  DESCRIPTION          = "Detector Singles Counters 1 to 6."
END_OBJECT             = COLUMN
OBJECT                 = COLUMN
  NAME                 = GOOD
  COLUMN_NUMBER        = 16
  START_BYTE           = 140
  BYTES                = 5
  DATA_TYPE            = ASCII_INTEGER
  FORMAT               = I5
  UNIT                 = "N/A"
  DESCRIPTION          = "Good Event Counter."
END_OBJECT             = COLUMN
OBJECT                 = COLUMN
  NAME                 = REJECT
  COLUMN_NUMBER        = 17
  START_BYTE           = 146
  BYTES                = 5
  DATA_TYPE            = ASCII_INTEGER
  FORMAT               = I5
  UNIT                 = "N/A"
  DESCRIPTION          = "Event Reject Counter."
```

```
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = TOTAL
  COLUMN_NUMBER      = 18
  START_BYTE         = 152
  BYTES              = 5
  DATA_TYPE          = ASCII_INTEGER
  FORMAT             = I5
  UNIT               = "N/A"
  DESCRIPTION        = "Total Event Counter."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = MOONVEC
  COLUMN_NUMBER      = 19
  START_BYTE         = 158
  BYTES              = 35
  ITEM_BYTES         = 11
  ITEM_OFFSET        = 12
  ITEMS              = 3
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "E11.4"
  UNIT               = KM
  DESCRIPTION        = "Spacecraft to Moon vector (J2000)."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = SUNVEC
  COLUMN_NUMBER      = 20
  START_BYTE         = 194
  BYTES              = 35
  ITEM_BYTES         = 11
  ITEM_OFFSET        = 12
  ITEMS              = 3
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "E11.4"
  UNIT               = KM
  DESCRIPTION        = "Spacecraft to Sun vector (J2000)."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = CRATERVEC
  COLUMN_NUMBER      = 21
  START_BYTE         = 230
  BYTES              = 35
  ITEM_BYTES         = 11
  ITEM_OFFSET        = 12
  ITEMS              = 3
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "E11.4"
  UNIT               = "N/A"
  DESCRIPTION        = "CRaTER Boresight unit vector (J2000)."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = ALTITUDE
  COLUMN_NUMBER      = 22
  START_BYTE         = 266
  BYTES              = 11
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "E11.4"
  UNIT               = KM
```

```
  DESCRIPTION         = "Altitude above lunar surface."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = NADIR
  COLUMN_NUMBER       = 23
  START_BYTE          = 278
  BYTES               = 11
  DATA_TYPE           = ASCII_REAL
  FORMAT              = "E11.4"
  UNIT                = DEGREES
  DESCRIPTION         = "Angle between CRaTER boresight and nadir."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = GSEVEC
  COLUMN_NUMBER       = 24
  START_BYTE          = 290
  BYTES               = 35
  ITEM_BYTES          = 11
  ITEM_OFFSET         = 12
  ITEMS               = 3
  DATA_TYPE           = ASCII_REAL
  FORMAT              = "E11.4"
  UNIT                = KM
  DESCRIPTION         = "Earth to CRaTER vector in GSE coordinates."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = GSMVEC
  COLUMN_NUMBER       = 25
  START_BYTE          = 326
  BYTES               = 35
  ITEM_BYTES          = 11
  ITEM_OFFSET         = 12
  ITEMS               = 3
  DATA_TYPE           = ASCII_REAL
  FORMAT              = "E11.4"
  UNIT                = KM
  DESCRIPTION         = "Earth to CRaTER vector in GSM coordinates."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = LATITUDE
  COLUMN_NUMBER       = 26
  START_BYTE          = 362
  BYTES               = 11
  DATA_TYPE           = ASCII_REAL
  FORMAT              = "E11.4"
  UNIT                = DEGREES
  DESCRIPTION         = "Selenographic crust-fixed north latitude of CRaTER."
END_OBJECT            = COLUMN
OBJECT                = COLUMN
  NAME                = LONGITUDE
  COLUMN_NUMBER       = 27
  START_BYTE          = 374
  BYTES               = 11
  DATA_TYPE           = ASCII_REAL
  FORMAT              = "E11.4"
  UNIT                = DEGREES
  DESCRIPTION         = "Selenographic crust-fixed east longitude of CRaTER."
END_OBJECT            = COLUMN
```

E.3 Level 2 Housekeeping Record (CRAT_L2_HK.FMT)

```
OBJECT                  = COLUMN
  NAME                  = SECONDS
  COLUMN_NUMBER         = 1
  START_BYTE            = 1
  BYTES                 = 9
  DATA_TYPE             = ASCII_INTEGER
  FORMAT                = I9
  UNIT                  = SECONDS
  DESCRIPTION           = "Elapsed time from 0h UT Jan 1 2001 to timing pulse."
END_OBJECT              = COLUMN
OBJECT                  = COLUMN
  NAME                  = FRACT
  COLUMN_NUMBER         = 2
  START_BYTE            = 11
  BYTES                 = 2
  DATA_TYPE             = ASCII_INTEGER
  FORMAT                = I2
  UNIT                  = "1/100 SECOND"
  DESCRIPTION           = "Hundredths of a second from 1 Hz pulse."
END_OBJECT              = COLUMN
OBJECT                  = COLUMN
  NAME                  = TIME
  COLUMN_NUMBER         = 3
  START_BYTE            = 15
  BYTES                 = 19
  DATA_TYPE             = TIME
  FORMAT                = A19
  UNIT                  = "N/A"
  DESCRIPTION           = "1 Hz Timing Pulse time in UTC."
END_OBJECT              = COLUMN
OBJECT                  = COLUMN
  NAME                  = FPGA_SN
  COLUMN_NUMBER         = 4
  START_BYTE            = 36
  BYTES                 = 2
  DATA_TYPE             = ASCII_INTEGER
  FORMAT                = I2
  UNIT                  = "N/A"
  DESCRIPTION           = "FPGA Revision Code."
END_OBJECT              = COLUMN
OBJECT                  = COLUMN
  NAME                  = V28BUS
  COLUMN_NUMBER         = 5
  START_BYTE            = 39
  BYTES                 = 7
  DATA_TYPE             = ASCII_REAL
  FORMAT                = "F7.3"
  UNIT                  = VOLTS
  DESCRIPTION           = "28VDC Monitor."
END_OBJECT              = COLUMN
OBJECT                  = COLUMN
  NAME                  = V5DIGITAL
  COLUMN_NUMBER         = 6
  START_BYTE            = 47
  BYTES                 = 7
```

```
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "F7.3"
  UNIT               = VOLTS
  DESCRIPTION        = "+5VDC Digital Monitor."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = VANALOGERR
  COLUMN_NUMBER      = 7
  START_BYTE         = 55
  BYTES              = 2
  DATA_TYPE          = ASCII_INTEGER
  FORMAT             = I2
  UNIT               = "N/A"
  DESCRIPTION        = "Analog Voltage Indicator (0: on; 15: off, so H/K is
                       invalid)."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = V5PLUS
  COLUMN_NUMBER      = 8
  START_BYTE         = 58
  BYTES              = 7
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "F7.3"
  UNIT               = VOLTS
  DESCRIPTION        = "+5VDC Analog Monitor."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = V5NEG
  COLUMN_NUMBER      = 9
  START_BYTE         = 66
  BYTES              = 7
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "F7.3"
  UNIT               = VOLTS
  DESCRIPTION        = "-5VDC Analog Monitor."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = I28BUS
  COLUMN_NUMBER      = 10
  START_BYTE         = 74
  BYTES              = 7
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "F7.3"
  UNIT               = VOLTS
  DESCRIPTION        = "+2.5VDC Internal Reference."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = P28BUS
  COLUMN_NUMBER      = 11
  START_BYTE         = 82
  BYTES              = 7
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "F7.3"
  UNIT               = WATTS
  DESCRIPTION        = "Instrument power (V28bus*I28bus)."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = BIASCURRENT
```

```
  COLUMN_NUMBER      = 12
  START_BYTE         = 90
  BYTES              = 47
  ITEM_BYTES         = 7
  ITEM_OFFSET        = 8
  ITEMS              = 6
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "F7.3"
  UNIT               = AMPS
  DESCRIPTION        = "Detector Bias Current Monitors."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = BIASVOLTTHIN
  COLUMN_NUMBER      = 13
  START_BYTE         = 138
  BYTES              = 7
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "F7.3"
  UNIT               = VOLTS
  DESCRIPTION        = "Thin Detector Bias Monitor voltage."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = BIASVOLTTHICK
  COLUMN_NUMBER      = 14
  START_BYTE         = 146
  BYTES              = 7
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "F7.3"
  UNIT               = VOLTS
  DESCRIPTION        = "Thick Detector Bias Monitor voltage."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = CALAMP
  COLUMN_NUMBER      = 15
  START_BYTE         = 154
  BYTES              = 7
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "F7.3"
  UNIT               = VOLTS
  DESCRIPTION        = "Electrical Calibration Amplitude Monitor."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = LLDTHIN
  COLUMN_NUMBER      = 16
  START_BYTE         = 162
  BYTES              = 7
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "F7.3"
  UNIT               = VOLTS
  DESCRIPTION        = "Thin Detector LLD Voltage Monitor."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = LLDTHICK
  COLUMN_NUMBER      = 17
  START_BYTE         = 170
  BYTES              = 7
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "F7.3"
```

```
  UNIT                 = VOLTS
  DESCRIPTION          = "Thick Detector LLD Voltage Monitor."
END_OBJECT             = COLUMN
OBJECT                 = COLUMN
  NAME                 = TTELESCOPE
  COLUMN_NUMBER        = 18
  START_BYTE           = 178
  BYTES                = 7
  DATA_TYPE            = ASCII_REAL
  FORMAT               = "F7.2"
  UNIT                 = CELSIUS
  DESCRIPTION          = "Telescope Temperature."
END_OBJECT             = COLUMN
OBJECT                 = COLUMN
  NAME                 = TANALOG
  COLUMN_NUMBER        = 19
  START_BYTE           = 186
  BYTES                = 7
  DATA_TYPE            = ASCII_REAL
  FORMAT               = "F7.2"
  UNIT                 = CELSIUS
  DESCRIPTION          = "Analog Board Temperature."
END_OBJECT             = COLUMN
OBJECT                 = COLUMN
  NAME                 = TDIGITAL
  COLUMN_NUMBER        = 20
  START_BYTE           = 194
  BYTES                = 7
  DATA_TYPE            = ASCII_REAL
  FORMAT               = "F7.2"
  UNIT                 = CELSIUS
  DESCRIPTION          = "Digital Board Temperature."
END_OBJECT             = COLUMN
OBJECT                 = COLUMN
  NAME                 = TPOWER
  COLUMN_NUMBER        = 21
  START_BYTE           = 202
  BYTES                = 7
  DATA_TYPE            = ASCII_REAL
  FORMAT               = "F7.2"
  UNIT                 = CELSIUS
  DESCRIPTION          = "Power Supply Temperature."
END_OBJECT             = COLUMN
OBJECT                 = COLUMN
  NAME                 = TREF
  COLUMN_NUMBER        = 22
  START_BYTE           = 210
  BYTES                = 7
  DATA_TYPE            = ASCII_REAL
  FORMAT               = "F7.2"
  UNIT                 = CELSIUS
  DESCRIPTION          = "Bulkhead Reference Temperature."
END_OBJECT             = COLUMN
OBJECT                 = COLUMN
  NAME                 = RADHIGHSENS
  COLUMN_NUMBER        = 23
  START_BYTE           = 218
  BYTES                = 10
```

```
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "E10.4"
  UNIT               = RADS
  DESCRIPTION        = "High Sensitivity Radiation monitor voltage."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = RADMEDSENS
  COLUMN_NUMBER      = 24
  START_BYTE         = 229
  BYTES              = 10
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "E10.4"
  UNIT               = RADS
  DESCRIPTION        = "Medium Sensitivity Radiation monitor voltage."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = RADLOWSENS
  COLUMN_NUMBER      = 25
  START_BYTE         = 240
  BYTES              = 10
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "E10.4"
  UNIT               = RADS
  DESCRIPTION        = "Low Sensitivity Radiation monitor voltage."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = TPRT
  COLUMN_NUMBER      = 26
  START_BYTE         = 251
  BYTES              = 10
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "E10.4"
  UNIT               = CELSIUS
  DESCRIPTION        = "PRT Reference (Ground Test Only)."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = PURGE
  COLUMN_NUMBER      = 27
  START_BYTE         = 262
  BYTES              = 10
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "E10.4"
  UNIT               = "CUBIC FEET PER HOUR"
  DESCRIPTION        = "Purge Flow Rate (Ground Test Only)."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = RADTOTAL
  COLUMN_NUMBER      = 28
  START_BYTE         = 273
  BYTES              = 10
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "E10.4"
  UNIT               = RADS
  DESCRIPTION        = "Cumulative instrument radiation dosage."
END_OBJECT           = COLUMN
OBJECT               = COLUMN
  NAME               = BIASENERGY
  COLUMN_NUMBER      = 29
```

```
  START_BYTE         = 284
  BYTES              = 65
  ITEM_BYTES         = 10
  ITEM_OFFSET        = 11
  ITEMS              = 6
  DATA_TYPE          = ASCII_REAL
  FORMAT             = "E10.4"
  UNIT               = "ELECTRON VOLTS"
  DESCRIPTION        = "Detector Bias Monitor energies."
END_OBJECT           = COLUMN
```