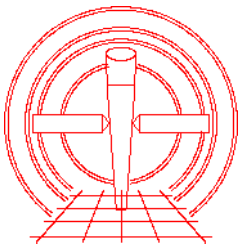
AXAF Science Center



ACIS Telemetry Products:
Level 0 to ASC Archive Interface Control Document

Rev. 2.10 — April 5, 1999

Submitted: _____ _____
Joel Kastner — Date
ACIS Scientist, ASC Science Data Systems

Concurred: _____ _____
David Huenemoerder — Date
MIT/ASC Science Manager

Concurred: _____ _____
Gregg Germain — Date
ASC Data Systems Group Leader, Level 0 Pipelines

Concurred: _____ _____
Arnold Rots — Date
ASC Archive Scientist

Concurred: _____ _____
Janet DePonte — Date
Manager, ASC Data Systems

Concurred: _____ _____
Martin Elvis — Date
Manager, ASC Science Data Systems

Approved: _____ _____
Harvey Tananbaum — Date
Director, ASC

Document and Change Control Log			
Date	**Version**	**Section**	**Status**
04/30/97	0.3	all	Original release
09/09/97	0.4	all	Preliminary version for MIT/ASC review
09/18/97	1.0	all	First ASC-wide release; lead author: P. Ford
10/09/97	1.1	all	JHK assumes control; RB, WMcL, DPH comments
10/21/97	1.2	4	JMcD, DA comments
11/7/97	1.3	2,4	more JHK, JMcD, DA comments
12/17/97	1.4	4	updates to bias maps & keywords, coords ranges
12/23/97	1.4.1	4	added provisional raw, histogram, SW HK products
1/27/98	2.0	4	made compliant w/ ASC-FITS-1.0 added raw, hist, SW HK and mem. dump products (internal MIT/ASC release only)
2/9/98	2.1	2,3,4	PGF, DA comments
2/24/98	2.2	2,3,4	DA, AR, WMcL comments
4/23/98	2.3	4	changes to filenames, column units, & a few headers
6/12/98	2.4	4	changes to: filenames; units; HK generation paradigm (limited release)
6/26/98	2.5	all	DA, PGF comments
6/30/98	2.6	4	Improved description of origin of TIME fields
7/27/98	2.7	4	incorporated DA, WMcL comments; improved CC mode time description
12/16/98	2.8	3,4	revamped DEA HK; changed hex keyword formats; clarified exr description; added srp product; added “quick-look” and bias-only SR requirements; added CC 3x3 mode file spec; defined TIMEDEL keywords
2/10/99	2.9	1,4	Fixed TFORM/TLMAX inconsistency in Table 26 (now 27); added CC 3x3 Graded mode (new Table 19) and added explanatory text; described handling of bad packets
04/05/99	2.10	3,4	Eliminated various TBDs; added missing exp. record keywords to raw mode (image) products

CONTENTS

1.0 Introduction 1
1.1 Purpose 1
1.2 Scope 1
1.3 Applicable Documents 1
1.4 Functional Description 1
1.4.1 Data Content Summary 1
1.4.2 Source and Transfer Method 2
1.4.3 Recipients and Utilization 2
1.4.4 Pertinent Relationships with Other Interfaces 2
1.5 Assumptions and Constraints 2
1.6 Other Modes and Formats 3

2.0 Environment 4
2.1 Hardware Characteristics and Limitations 4
2.2 Interface Medium and Characteristics 4
2.3 Failure Protection, Detection, and Recovery Features 4
2.3.1 Backup Requirements 4
2.3.2 Security / Integrity Measures 4
2.4 End-Of-File (or Medium) Conventions 4

3.0 Access 5
3.1 Access Tools; Input / Output Protocol 5
3.2 Timing and Sequencing Characteristics 5
3.2.1 Archived Products 5
3.2.2 Quick-look (M&TA) Products 5

4.0 Detailed Interface Specifications 6
4.1 Labeling and Identification 6
4.2 Structure and Organization Overview 7
4.3 The Origin and Content of Time Fields 7
4.3.1 Science Products (Tables 1 and 2) 7
4.3.2 Housekeeping (HK)/Monitoring Products (Table 3) 9
4.4 Substructure Definition and Format 10
4.4.1 Header / Trailer Description Details 10
4.4.2 Parameter Block Files (*_pbk0.fits) 13
4.4.3 Window Block Files (*_win0.fits) 16
4.4.4 Exposure Record Files (*_f_exr0.fits) 17
4.4.5 Bias Error Files (*_f_berr0.fits) 19
4.4.6 Timed-Exposure Event Files (*_f_evt0.fits) 20
4.4.7 Continuous Clocking Event Files (*_f_evt0.fits) 24
4.4.8 Science Run Report File (*_srr0.fits) 26
4.4.9 Science Run Product Summary File (*_srp0.fits) 27
4.4.10 Bias Map Files (*_f_bias0.fits) 28
4.4.11 Raw Mode (Image) Files (*_fEeee_img0.fits) 32
4.4.12 Histogram Files (*_fNnEeee_hist0.fits) 37

4.4.13 DEA Housekeeping Files (*_hkp0.fits) 38
4.4.14 System Configuration Table Files (*_sys0.fits) 39
4.4.15 Software Housekeeping Files (*_swhkp0.fits) 41
4.4.16 Memory Dump Files (*_t_mem0.fits) 41
4.5 Volume, Size, and Frequency Estimates. 42

Appendix A: IP&CL Fields and MSID Keywords A-1

Appendix B: ACIS Constants B-1
B.1 CCD Identifiers. B-1
B.2 CCD Row and Column Position Definition B-1
B.3 Event Grade Code Definition B-2
B.4 FEP Identifiers B-3
B.5 Output Register Clocking Modes B-3
B.6 DEA Query Identifiers B-3
B.7 Bias Algorithm Selection Codes. B-5
B.7.1 Timed Exposure Mode B-5
B.7.2 Continuous Clocking Mode B-6
B.8 FEP Science Report Error Codes B-6
B.9 FEP Science Mode Codes. B-7
B.9.1 Timed Exposure Mode B-7
B.9.2 Continuous Clocking Mode B-8
B.10 BEP Packing Mode Codes B-9
B.10.1 Timed Exposure B-9
B.10.2 Continuous Clocking B-9
B.11 Science Mode Termination Codes B-9
B.12 Miscellaneous FEP Constants. B-10
B.13 Miscellaneous BEP Constants B-10

LIST OF TABLES

Table 1: ACIS Level 0 Timed-Exposure Data Product Files 6
Table 2: ACIS Level 0 Continuous Clocking Data Product Files 7
Table 3: ACIS Level 0 Housekeeping (HK) Data Product Files 7
Table 4: Format of a Level 0 Auxilliary Null FITS Keyword Header. 10
Table 5: Format of a Level 0 FITS Principal Binary Table Extension Header 12
Table 6: Timed Exposure Parameter Block File 13
Table 7: Continuous Clocking Parameter Block File 14
Table 8: 2-Dimensional Window Block File 16
Table 9: 1-Dimensional Window Block File 16
Table 10: Exposure Records File 17
Table 11: Bias Error File 19
Table 12: TE Faint Event Data File 20
Table 13: TE Faint-with-bias Event Data File 21
Table 14: TE Graded Event Data File 21
Table 15: TE Very Faint Event Data File. 23
Table 16: CC (1x3) Faint Event Data File 24
Table 17: CC 3x3 Faint Event Data File 24
Table 18: CC (1x3) Graded Event Data File 25
Table 19: CC 3x3 Graded Event Data File 25
Table 20: Science Run Report File 26
Table 21: Science Run Product Summary File 27
Table 22: TE Bias Map File 28
Table 23: CC Bias Map File 30
Table 24: TE Image File 33
Table 25: CC Image File 35
Table 26: Histogram File 37
Table 27: DEA Housekeeping File 38
Table 28: System Configuration File 39
Table 29: Software Housekeeping File 41
Table 30: Memory Dump File 41

Table A–1: Traceability between ACIS IP&CL fields and MSID keywords A-1
Table B–1: CCD_ID Values B-1
Table B–2: FEP_ID Values B-3
Table B–3: ORC_MODE Values. B-3
Table B–4: DEA Controller QUERY_ID Values B-3
Table B–5: DEA Analog QUERY_ID Values. B-5
Table B–6: BIASALG Values B-5
Table B–7: Timed Exposure Bias Parameter Usage. B-6
Table B–8: Continuous Clocking Bias Parameter Usage B-6
Table B–9: FEP_ERRS Values. B-7
Table B–10: Timed-Exposure FEP_MODE Values. B-7
Table B–11: Continuous Clocking FEP_MODE Values B-8
Table B–12: Timed Exposure BEP_MODE Values B-9
Table B–13: Continuous Clocking BEP_MODE Values B-9
Table B–14: TERMCODE Values. B-9
Table B–15: Miscellaneous FEP Constants B-10
Table B–16: Miscellaneous BEP Constants B-10

LIST OF UNDETERMINED ITEMS

1. Data products not covered by this document 3
2. Means by which products are transmitted to the Archive 4
3. Document describing conversion of VCDU counters to TT times 8
4. Final document reference for ACIS flight SW User's Guide 9
5. Define volume, size, and frequency estimates 42

1.0 Introduction

This document describes the interface to be employed in transferring telemetry data from the ACIS instrument between the ASC Level 0 processing pipeline and the ASC Data Archive, according to the requirements stipulated in Applicable Document 6.

1.1 PURPOSE

ACIS Level 0 processing, described in Applicable Document 7, extracts the ACIS science portions of the CTUE telemetry frames. It then decodes (decommutates) the packet streams contained in these portions, according to the ACIS flight software requirements specifications (Applicable Document 1) and, more specifically, according to the ACIS IP&CL definitions (Applicable Document 3).

1.2 SCOPE

This interface shall apply to all ACIS telemetry data sets that are generated by ASC Level 0 pipelines during the course of the AXAF mission.

1.3 APPLICABLE DOCUMENTS

	Document	Description
1	MIT 36-01103 Rev. J	ACIS Flight Software Requirements Specification http://acis.mit.edu/sreqj/
2	MIT 36-53226 Rev. A	ACIS Flight Software Detailed Design Specification
3	MIT 36-53204 Rev. K	ACIS Instrument Procedures and Command Language http://acis.mit.edu/ipcl/
4	MIT 36-02205 Rev. C	ACIS DPA to DEA Interface Control Document http://acis.mit.edu/axaf/deadpaicd/
5	MIT 36-02203, Rev. A	ACIS Focal Plane to Detector Housing Interface Control Document
6	ASC AMO-2400 (SE03)	ASC Data System Requirements (ASC.302.93.0008)
7	ASC AMO-2401 (DS01)	ASC Data System Software Design (ASC.500.93.0006)
8	...	Definition of the Flexible Image Transport System (FITS) http://www.gsfc.nasa.gov/astro/fits/documents.html
9	ASC-FITS-1.3	ASC FITS File Designer's Guide http://hea-www.harvard.edu/~arots/asc/fits/ascfits.ps
10	...	CFITSIO User's Guide http://heasarc.gsfc.nasa.gov/docs/software/fitsio/user_c/user_c.html
11	content.txt	Guide to AXAF Data Products http://hea-www.harvard.edu/~arots/asc/fits/content.txt

1.4 FUNCTIONAL DESCRIPTION

1.4.1 Data Content Summary

All ACIS data sets generated by the Level 0 processing pipeline shall consist of digital data files

conforming to the FITS format (Applicable Document 8). These files contain header keyword entries and binary table (BINTABLE) extensions (except for bias files and raw-mode image files, which do not contain BINTABLE extensions). Each entry in these files, apart from generic ASC header keywords and certain items (such as time fields) otherwise indicated in this document, corresponds to an element in the ACIS science telemetry stream. The names of these keywords and table items are contained in a series of templates, listed in Appendix A, which serve as cross-references between ACIS packet contents and Level 0 data products. Appendix B lists some useful telemetry flag field values.

1.4.2 Source and Transfer Method

ACIS Level 0 products shall be created by the ACIS Data Extractor described in §4.5.3.4.2 of Applicable Document 7.

1.4.3 Recipients and Utilization

It is anticipated that the primary recipients of the data products described in this document will be the ASC Data Archive, and that the archived Level 0 data products subsequently will be accessed and utilized primarily by the ASC Level 1 ACIS data processing pipeline. Certain Level 0 products, in particular Bias Map files, also may be routinely distributed directly to the PI of the AXAF observation. It is also anticipated that, in certain cases, PIs of AXAF observing programs may request, and will be granted, direct access to any or all of the other Level 0 products. Identification of additional recipients of Level 0 products, and the uses to which they may wish to put them, falls beyond the scope of this document.

1.4.4 Pertinent Relationships with Other Interfaces

Changes to the definition of ACIS science telemetry packets and their data fields, as specified in Applicable Document 3, may affect the Level 0 data products described in the current document.

1.5 ASSUMPTIONS AND CONSTRAINTS

For each ACIS science event run reported in the AXAF telemetry stream, Level 0 processing shall generate a set of product files as shown in Table 3 (timed exposure; TE) or Table 2 (continuous clocking; CC). Since all runs use either Timed-Exposure or Continuous-Clocking mode, either a CC or a TE parameter block file shall always be generated. If the parameter block specified window selection filters, the appropriate window file shall be generated.

Each ACIS Front End Processor (FEP) that generates event telemetry will be represented by a pair of data files—an exposure file that summarizes the exposure epoch and number of candidate events within each CCD frame, and an event file that contains the events themselves. As the raw data comprising both files are received in time order, consistent with the requirements in §5.3 and §5.4 of Applicable Document 6, no sorting is required so long as the data files are constructed independently for each FEP. Pixel addresses are expressed in CCD coordinates in which the row and column indices in principle span the range 0–1023, where the (0,0) origin is the pixel nearest to output node A of the CCD. These coordinates are referred to in the present document as CCDX,CCDY so as to avoid confusion with the CHIPX,CHIPY coordinate system used in Level 1 processing. In practice, CCD coordinates can only span the range 1-1022, since events cannot be detected at the edges of the CCD.

CCD bias pixel packets will be assembled into bias image files in FITS format. If, however, the

bias maps were never received, they will be omitted from the Level 0 product. Timed-exposure bias maps shall contain 1024x1024 pixels. Continuous clocking bias maps shall contain 1024x512 pixels, where all 512 rows of the CC bias map replicate the same CC bias row.

Any bias pixel error packets encountered during Level 0 processing shall be assembled into Bad Bias Pixel files, one for each FEP that reports bias errors.

ACIS telemetry packets deemed to be bad (due to, e.g., telemetry minor frame corruption) will be "dumped" into Bad Packet files. These files will be in the so-called ASC Level 0 "strip file" format, which is not described in this ICD.

1.6 OTHER MODES AND FORMATS

The following categories of ACIS telemetry are used for maintenance and diagnostic purposes; descriptions are included within the interface defined by this document, but are somewhat preliminary in certain cases (e.g., Memory Dumps):

- Data derived from Timed-Exposure and Continuous-clocking Raw (image) modes
- Data derived from Timed-Exposure Histogram modes (pixels and events)
- Memory Dumps (except the System Configuration Table)
- Back-End Processor Software Housekeeping
- DEA Housekeeping ("raw" and calibrated)

The following categories are not yet covered by this document (TBD):

- Start-up messages
- Fatal error messages
- Command Verification

2.0 Environment

2.1 HARDWARE CHARACTERISTICS AND LIMITATIONS

All integers within ACIS Level 0 products are written in "big-endian" format, i.e. with their more significant bytes preceding their less significant bytes. Within FITS keyword headers, unsigned integer values are represented as positive decimal quantities. Within FITS binary table extensions, unsigned *n*-byte integers whose most significant bit can be ON[1] shall be described by `TFORM` values of `1U` (for 2-byte unsigned integers) or `1V` (for 4-byte unsigned integers). This results in the appropriate cfitsio calls to scale the data appropriately via the `TZERO` keyword. See Applicable Document 10.

These products contain double-precision floating point fields. They are written in IEEE-754 format, using the "big-endian" convention, *i.e.* the sign bit and the high-order 7 bits of the exponent are in the first byte, the 4 low-order bits of the exponent and the 4 high-order bits of the mantissa are in the second byte, and so on. Special values, *e.g.* `NaN`, shall not occur.

2.2 INTERFACE MEDIUM AND CHARACTERISTICS

Level 0 products shall be created on a UNIX file system. While they are being written, their FITS headers may contain invalid keyword values (*e.g.* `NAXIS2`, the number of binary table rows), and the bias image files may be sparse. Care must be taken not to read or copy these files until they are complete.

2.3 FAILURE PROTECTION, DETECTION, AND RECOVERY FEATURES

2.3.1 Backup Requirements

Once created, ACIS Level 0 products are transmitted to the ASC Archive by TBD means. All further responsibility for the products rests with the Archive.

2.3.2 Security / Integrity Measures

The keyword headers of all Level 0 products shall contain an indication of their total byte length so that a file truncation can be detected. For bias image files, this is $|L_{HDR}|_{2880} + |2*x*y|_{2880}$, where L_{HDR} is the length of the keyword header (in bytes), x is the value of the `NAXIS1` header keyword, y is the value of the `NAXIS2` header keyword, and $|n|_{2880}$ denotes the smallest multiple of 2880 that is greater than, or equal to, n. The equivalent expression for the length of a Level 0 binary table file is $|L_{HDR}|_{2880} + |L_{THDR}|_{2880} + |2*x*y|_{2880}$, where L_{THDR} is the byte length of the binary table header, and x and y are the values of `NAXIS1` and `NAXIS2` within that header.

Equivalently (and perhaps preferentially), a 32-bit integer one's complement checksum of each extension, and hence the entire file, should be -0 (all ones).

2.4 END-OF-FILE (OR MEDIUM) CONVENTIONS

All Level 0 products obey the FITS conventions of Applicable Document 8—headers are terminated by "`END`" keywords; the size of image arrays and binary tables is defined by the `NAXIS1` and `NAXIS2` header keywords.

---

1. i.e. $T_{max} > 2^{8*n-1}-1$, where T_{max} is the `TLMAX` value of the n-byte data field.

3.0 Access

3.1 ACCESS TOOLS; INPUT / OUTPUT PROTOCOL

Since ACIS Level 0 products obey the formatting rules described in Applicable Document 8, they may be accessed by any software that conforms to those standards, including all versions of the `FITSIO` libraries that support the `BINTABLE` extension and unsigned integer formats (see Applicable Documents 8 and 10). Given the method by which some unsigned integer fields are represented (see Section 2.1, above), care must be taken in converting these fields to numeric values.

3.2 TIMING AND SEQUENCING CHARACTERISTICS

The natural subdivision ("atomic unit") of ACIS telemetry is the Science Run (SR), which signals its start by writing a `dumpedTeBlock` or `dumpedCcBlock` packet to the science telemetry stream, and which continues through the output of a `scienceRunReport` packet (which signals Science Run termination). By contrast, the natural subdivision of AXAF data is the Observation Request (OR), which may in principle span several ACIS science runs. In most circumstances, however, we expect there to be a one-to-one correpondence between SRs and ORs (note that an OR consisting of more than one SR would result in the production of more than one set of science data products).

3.2.1 Archived Products

For archival purposes, science data products (Tables 1 or 2) are processed and produced per SR; that is, output products will be opened following the appearance of the `dumpedTeBlock` or `dumpedCcBlock` packet and closed following the appearance of the `scienceRunReport` packet. The Product Summary File (Tables 1 or 2) is the last file produced by Level 0 decommutation software, upon completion of processing of each Science Run, and hence can be used to flag the availability of products (summarized therein) for archival.

Aside from DEA Housekeeping (HK) products, which contain multiple packets and are opened and closed on SR boundaries (subject to file size criteria), HK products are produced on a packet by packet basis. As DEA HK packets also may appear between SRs, the correpondence between OR and SR may break down even for DEA HK files. Hence, the numbers and types of HK files output by Level 0 is dependent on the ACIS command history.

3.2.2 Quick-look (M&TA) Products

To comply with AXAF Monitoring and Trends Analysis requirements (see Sec. 5.3.3 of Applicable Document 6), ACIS Level 0 processing shall also have the capability to close any open ACIS Level 0 files arbitrarily, regardless of the state of completion of the SR. It is envisioned that such processing shall occur in the "quick look" realm, i.e., as a process entirely separate from that of the Level 0 product archival process just described. M&TA users of these "quick look" products are cautioned that "quick look" products generated from "partial" SRs: (a) may contain spurious data (e.g., meaningless or misleading `TSTART, TSTOP` values); (b) likely will be cumulative (i.e., will contain data from the start of a SR until the time of interest) rather than being limited, e.g., to a particular 8-hour telemetry segment; (c) will not be archived (by definition).

4.0 Detailed Interface Specifications

4.1 LABELING AND IDENTIFICATION

The data files generated by the Level 0 processing pipeline shall be assigned external names as shown in Table 3 (for ACIS Timed-Exposure mode) and Table 2 (for Continuous Clocking mode). Housekeeping/monitoring data products are assigned names as in Table 3. The names obey the following convention (see `http://hea-www.harvard.edu/~arots/asc/archive/files.html`):

`aciss`*`000000000`*`N`*`000_f_product`*`0.fits`

where '*`s`*' denotes the origin of the data (possible values: `x = XRCF, f = flight, t = TRW, b = Ball, s = simulation`), '*`000000000`*' is a 9-digit time stamp indicating the time of the start of the Science Run (Table 1 and 2 products) or time of packet generation (Table 3 products) in seconds since Dec. 31 1993 (equivalent to the value of runStartTime in the ACIS IP&CL [Applicable Document 3] and `RUNSTART` in certain extension headers; see Sec. 4.3), `N`*`000`* denotes a processing run (or version) number, and the (optional) '*`f`*' denotes the index of a particular ACIS front end processor (FEP) or another filename discriminator (see below). The '0' just before the filename suffix identifies this as a Level 0 file.

The filename discriminator ('*`f`*') can be augmented in various ways, depending on file type. For Histogram files only, '`N`*`n`*`E`*`eee`*' is appended to the FEP number, to indicate the CCD node ('*n*') for which the histogram was compiled and the number of the first exposure ('*eee*') used to generate the histogram. The field 'E*eee*' also represents the exposure number for "raw" (image) mode data files. For memory dump files only, the field '*t*' (replacing '*f*') denotes the type of memory dump (see Section 4.4.16).

Table 1: ACIS Level 0 Timed-Exposure Data Product Files

Title	File Name	Contents
TE Parameter File	`*_pbk0.fits`	Timed exposure (TE) science run parameters
2-D Window File	`*_win0.fits`	Optional TE (2-dimensional) window filter parameters
Science Report File	`*_srr0.fits`	Science run report (common to TE and CC modes)
Product Summary File	`*_srp0.fits`	Data Product Summary (common to TE and CC modes)
Exposure File	`*_`*`f`*`_exr0.fits`	Per-exposure statistics, one per FEP
Bias Error File	`*_`*`f`*`_berr0.fits`	Optional bias pixel parity errors, one per FEP
TE Event File	`*_`*`f`*`_evt0.fits`	TE events, in one of faint (3x3), faint w/ bias (3x3), very faint (5x5), or graded event file formats
Bias File	`*_`*`f`*`_bias0.fits`	TE CCD bias array file, one per FEP
Image File	`*_`*`f`*`Eeee_img0.fits`	TE CCD image (raw mode only), one per FEP, for exposure *e*
Histogram File	`*_`*`f`*`N`*`n`*`Eeee_hist0.fits`	Histogram of CCD pixel (or event) values, for node *n* and exposure *eee* (TE histogram mode only)

Table 2: ACIS Level 0 Continuous Clocking Data Product Files

Title	File Name	Contents
CC Parameter File	`*_pbk0.fits`	Continuous clocking (CC) science run parameters
1-D Window File	`*_win0.fits`	Optional CC (1-dimensional) window filter parameters
Science Report File	`*_srr0.fits`	Science run report (common to TE and CC modes)
Product Summary File	`*_srp0.fits`	Data Product Summary (common to TE and CC modes)
Exposure File	`*_f_exr0.fits`	Per-exposure statistics, one per FEP
Bias Error File	`*_f_berr0.fits`	Optional bias pixel parity errors, one per FEP
CC Event File	`*_f_evt0.fits`	CC events, in one of faint (1x3), 3x3, or graded event file formats
Bias File	`*_f_bias0.fits`	CC CCD bias array file, one per FEP
Image File	`*_fEeee_img0.fits`	CC CCD row 'image' (raw mode only), one per FEP, for exposure *eee*

Table 3: ACIS Level 0 Housekeeping (HK) Data Product Files

Title	File Name	Contents
DEA Housekeeping	`*_hkp0.fits`	DEA housekeeping report
System Configuration	`*_sys0.fits`	System configuration table
Software Housekeeping	`*_swhkp0.fits`	Software housekeeping report
Memory Dump File	`*_t_mem0.fits`	Memory dump of type *t* (bad pixels, patches, Huffman tables, etc).

4.2 STRUCTURE AND ORGANIZATION OVERVIEW

As previously noted, the Science Run forms a natural unit by which ACIS science telemetry can, and should, be divided. The Level 0 processing system shall therefore segregate its science products (Tables 1 and 2) by run number, where the run number (keyword `RUN_ID`) begins at 1 and increments until `OBS_ID` changes[1]. Since the ACIS instrument interleaves event telemetry from its CCDs in an unpredictable manner, the events from each CCD shall be written to a separate Level 0 file. The task of merging the events from individual CCDs into a single product is left for the Level 1 ACIS pipeline.

4.3 THE ORIGIN AND CONTENT OF TIME FIELDS

The reader is referred to Applicable Document 9, Section 2.1, for a detailed discussion of AXAF-specific time keywords.

4.3.1 Science Products (Tables 1 and 2)

All CCD exposures (frames) obtained by ACIS are tagged with the *inferred* value of the (nominally) 100 kHz BEP counter, whose value is reported at the start of each telemetry science frame (i.e., every 2.05 seconds). The BEP clock values may thereby be related to the more accurate spacecraft clock via the VCDU counters in the telemetry minor frame headers. Prior to ACIS

1. In cases in which there is no OBS_ID (e.g. XRCF, TRW), RUN_ID begins at 1 and increments for each Science Run encountered during a Level 0 processing run on a given block of telemetry.

Level 0 processing, the VCDU counters are themselves related to observatory Terrestrial Time (TT), *i.e.* earth receipt TT minus one-way light time, via a method described in a TBD document.

In the header keyword TSTART of most science data files (i.e. event files, exposure records, bias files) is recorded the S/C TT corresponding to the BEP counter value for the first CCD exposure processed[1] during the relevant portion of the science run (the values of DATE-OBS and TIME-OBS correspond to TSTART). The header keyword TSTOP is set to the time associated with the *end* of the last exposure processed; i.e. this keyword is set to TIME+EXPTIME where TIME is the time of the last exposure. Note that there will typically be more than one TSTART /TSTOP pair in the various data products associated with a given science run, since (for example) bias data collection will be conducted during one time interval within the science run while event data will be collected during another time interval within the science run. Hence, for event files (Table 12 through Table 18), exposure record files (Table 10), bias images (Table 24 and Table 23), raw mode images (Tables 21 and 22), or histogram files (Table 23), the TSTART /TSTOP values correspond to the time interval within the science run during which the data were obtained. For other data products generated during a science run (i.e. window and bias error files), the TSTART / TSTOP values correspond to the time interval of the entire science run[2]. The BEP clock values corresponding to a given TSTART and TSTOP are recorded as STARTBEP and STOPBEP, respectively. The start of the science run in BEP clock units (i.e. *runStartTime* in the ACIS IP&CL; Applicable Document 3) is also recorded in certain extension headers as RUNSTART.

The indices of the telemetry science frames which encompass the ACIS science run data in question are contained in STARTMJF, STARTMNF (which mark where in telemetry the DUMP_TE or DUMP_CC packets were found) and STOPMJF, STOPMNF. That is, the initial data for the science run in question are found in telemetry major frame STARTMJF, minor frame STARTMNF, while the last science run data (i.e. the *scienceReport* packet data) are found in minor frame STOPMJF, minor frame STOPMNF. The presence of these keywords, plus temporal information stored in the ASC Data Archive, allows one to recover the position of the science run in question from ACIS telemetry, if necessary.

Two time values are recorded for each frame in the exposure record files (see Section 4.4.4). These values are BEPSTAMP, the *inferred* BEP clock value (time stamp) at the start of the exposure, and TIME, the observatory timestamp derived for the exposure. The value of TIME corresponding to a given exposure is also placed in the record of each event detected and telemetered for that exposure (see Section 4.4.6 and Section 4.4.7); in the case of continuous clocking (CC) mode, a correction to the exposure record value of TIME is applied to each event, according to its position (TROW) within the 512-row block that constitutes a CC mode "exposure".

Hence, TIME is calculated according to the following, for exposures and events obtained in timed exposure (TE) and CC modes:

TE exposures: `TIME = t(BEPSTAMP) + 0.05*EXPTIME`
CC exposures: `TIME = t(BEPSTAMP)`

1. Typically, for example, two exposures are skipped (not reported) at the start of a Science Run; TSTART corresponds to the time of the first exposure *reported* by a given FEP, as determined from the exposure record packet immediately following a DUMP_TE or DUMP_CC packet.
2. TSTOP for bias images may be difficult to ascertain in practice, so we set TSTOP=TSTART. For Science Runs that consist of bias determination only, all products shall have TSTOP=TSTART.

TE events: `TIME = t(BEPSTAMP) + 0.05*EXPTIME`
CC events: `TIME = t(BEPSTAMP) + (TROW+.5)*EXPTIME*10^-5`

(where the "native" units of `EXPTIME` are 0.1 s for TE mode and 10^-5 seconds for CC mode). Note that exposure `TIME` values are calculated for mid-exposure for TE mode, and for exposure start for CC mode. TE event times are calculated for mid-exposure; CC mode event times are calculated for mid-row. For CC mode, `EXPTIME` is a derived rather than telemetered quantity, and is calculated from an expression (described in ACIS Science Instrument Software User's Guide, Section 4.1.1.1; document reference TBD), which depends on the intrinsic row clocking rate of ACIS and the value of the `OCLKPAIR` keyword in the Parameter Block file.

The value of `t(BEPSTAMP)`, i.e., the time corresponding to a given `BEPSTAMP`, is obtained by interpolation from a lookup table constructed from (VCDU, `BEPSTAMP`) pairs contained in each telemetry science frame. The value of `BEPSTAMP` is, in turn, derived from the value of `BEPSTAMP(t_0)`, the BEP counter value at Science Run start, as well as from the values of `EXPNO` and `BEP_EXPTIME` for the exposure in question[1], i.e.,

`BEPSTAMP = BEPSTAMP(t_0) + (EXPNO * BEP_EXPTIME)`
where `BEP_EXPTIME` is obtained from the difference in FEP timestamp (`FEPSTAMP`) values from two successive exposure record packets (typically, these are the first two exposure record packets telemetered at the start of the Science Run[2]). As a precaution and to facilitate bug tracking, the telemetered value of `FEPSTAMP` is included in each exposure record.

TIMEDEL keyword(s). For data obtained in Timed Exposure readout mode, the keyword `TIMEDEL` in exposure record files and event files represents the duration of an entire exposure cycle, and is obtained as

`TIMEDEL = TIMEDELA + (DTYCYCLE+1)*TIMEDELB`
where `TIMEDELA` is the inferred exposure duration of the primary exposure (obtained as the time in seconds between the start the primary exposure and the start of the first secondary exposure) and `TIMEDELB` is the inferred exposure duration of the secondary exposures (obtained as the time in seconds between starts of successive secondary exposures). Note that if `DTYCYCLE=0` then `TIMEDELB=0` and hence `TIMEDEL = TIMEDELA`.

For data obtained in Continuous Clocking readout mode, `TIMEDEL` is set equal to the nominal row readout time, which is also contained in `EXPTIME` (`TIMEDELA` and `TIMEDELB` are not present in CC mode file headers).

4.3.2 Housekeeping (HK)/Monitoring Products (Table 3)

The ACIS telemetry packets that generate HK products contain an alternative time field, `BEPCOUNT`. This represents the number of BEP software timer interrupts since the last processor reset. Although the nominal interrupt time is 100 milliseconds, this may vary with processor load; also, there is no fiducial value of `BEPCOUNT` in a telemetry frame, as was the case with `BEPSTAMP`. Thus, filenames for Table 3 products are assigned to these products based on the VCDU

1. If `DTYCYCLE` is non-zero (see Table 6), then the exposure times and numbers of primary and secondary exposures must be considered independently.
2. For Science Runs and/or data products containing data from only 1 exposure -- e.g., raw (image) files -- BEP_EXPTIME is obtained directly from EXPTIME, and all subsequent dependent times (e.g. TSTOP) shall be based on this estimated exposure duration.

index encoded within the telemetry minor frame containing the first data packet; TSTART and TSTOP values are determined from the telemetry minor frame VCDU indices corresponding to the first and last data packets, respectively; and we use the VCDU counter of the minor frame containing the housekeeping packet to determine, where relevant, the TIME value for the corresponding table entry in a housekeeping product.

TIMEDEL keyword. Since the frequency of reporting of HK items by ACIS flight software is indeterminate (depends on ACIS command history), TIMEDEL is not present for ACIS HK products described in this ICD.

4.4 SUBSTRUCTURE DEFINITION AND FORMAT

4.4.1 Header / Trailer Description Details

All ACIS Level 0 products shall consist of files in FITS format, as defined in Applicable Document 8. Each FITS file is comprised of a primary component and optional extension components (described in Applicable Document 9, for AXAF-specific cases). Each of these components is divided into two parts: a header section and an (optional) data section. The length of each section is a multiple of 2880 bytes. The header section is further subdivided into 80-byte "records" containing only ASCII characters.

With the exception of bias and raw mode image files (Section 4.4.10 and Section 4.4.11), all ACIS Level 0 files contain Binary Table extensions. In each of these cases, there is only one Table extension (the "Principal" extension). Hence all ACIS Level 0 products conform to one of two FITS file "designs" as defined in Applicable Document 9: Principal Image (bias files and raw mode image files) or Auxiliary Null + Principal Table (all other products). Table 4 shows the keyword sections that should be present in the headers of the Auxiliary Null section of all ACIS Level 0 products, according to Applicable Document 9 (its Table 6; see also Appendix 1 of that document). Each 80 byte line is left justified and ASCII blank filled on the right. Following the 'END' keyword, ASCII blanks are appended until the header length is a multiple of 2880 bytes (36 lines).

Table 4: Format of a Level 0 Auxilliary Null FITS Keyword Header

```
SIMPLE  =                    T / FITS STANDARD
BITPIX  =                    8 / Binary Data
NAXIS   =                    0 / No image data array present
EXTEND  =                    T / There may be standard extensions
COMMENT
COMMENT           AXAF FITS File: ACIS Level 0
COMMENT
.............Required keywords (see Applicable Document 9):..........
.............Section CC (null): configuration control keywords........
.............Section T (short): timing keywords.....................
.............Section O (short): observation info keywords............
END
```

The binary tables are further described by an extension header (the Principal Extension header) that immediately follows the Auxilliary Null header of Table 4. The format of such a "generic" FITS binary table extension follows the recommendations of Applicable Document 9 and is

shown in Table 5. The header, composed of lines of 80-byte ASCII characters, begins with a group of "required" keywords (XTENSION through GCOUNT), and continues with required AXAF keywords[1] , including enumerations for the keywords CONTENT and HDUCLASS/HDUCLASn in Applicable Document 11, followed by ACIS-specific keywords. Allowed values of READMODE and DATAMODE (not present in HK data products) appear in Table 5 of Applicable Document 9. The keyword RUN_ID (also not present in HK data products) contains an integer counter indicating science run number within the OBI. The value of FSW_VERS (Flight Software Version Number) is contained both in "bepStartupMessage" telemetry packets (as the field "version") and in the Software Housekeeping packets (see Section 4.4.15), which are entered into telemetry every 60 seconds. In the latter, it is encoded as "statistics[i].value" when "statistics[i].swStatisticId" is set to SWSTAT_VERSION. In the event a file containing the FSW_VERS keyword is to be closed prior to receiving a bepStartupMessage or Software Housekeeping packet, then FSW_VERS is set to 0 (i.e., FSW_VERS is UNKNOWN) .

These ACIS-specific keywords are followed by one or more product-specific keywords (the EXTNAME keyword, which defines the file type, is product-specific even though it is part of the "Mandatory" header component; the allowed values of this keyword are listed in Appendix 1 of Applicable Document 9). The header continues with TFIELDS and groups of keywords (TFORM*m* through TLMAX*m*) that define each column of the binary table that follows the FITS header (this is the Table Coordinate keyword section described in Applicable Document 9). After the terminating 'END' keyword, ASCII blanks are added until the length of the extension header is a multiple of 2880 bytes. In the following tables, each Level 0 product is defined in terms of its product-specific keywords and its binary table fields. Each is ultimately derived from ACIS science telemetry fields, defined in Applicable Document 3, and related to Measurement Stimulus Identifier (MSID) field names in Appendix A, Table 1.

The table itself immediately follows the extension header. Its length is determined by the values of the NAXIS1 and NAXIS2 keywords in the extension header (not those in the initial keyword header of Table 4), and blank bytes are added until it, too, is a multiple of 2880 bytes in length.

1. Level 0 data product files have special dispensation to use the short Observation Info component even in Principal primary and extension sections of FITS files.

Table 5: Format of a Level 0 FITS Principal Binary Table Extension Header

```
XTENSION= 'BINTABLE'      / This is a binary table
BITPIX  =                 8 / Bits per 'pixel'
NAXIS   =                 2 / Number of 'axes'
NAXIS1  =              size / Width of a table row in bytes
NAXIS2  =              rows / Number of rows of binary data
PCOUNT  =                 0 / Random parameter count (required but ignored)
GCOUNT  =                 1 / Number of data groups
TFIELDS =                 m / Number of data fields per row
EXTNAME = 'EXTNAME'       / extension name; usually same as HDUNAME
COMMENT
.............Required keywords (see Applicable Document 9):...........
.............Section CC: configuration control keywords..............
.............Section T: timing keywords.............................
.............Section O (short): observation info keywords.............
COMMENT
COMMENT            AXAF FITS File: ACIS-specific Keywords
COMMENT
READMODE= 'TIMED    '             / CCD exposure mode
DATAMODE= 'FAINT    '             / CCD event telemetry mode
RUN_ID  =                       1 / Science run index
FSW_VERS=                       0 / ACIS flight software version number
STARTBEP=                       0 / BEP timer value at TSTART
STOPBEP=                        0 / BEP timer value at TSTOP
COMMENT
COMMENT  Product-specific keywords are inserted here
COMMENT
.............Section TC:table coordinate keywords.....................
COMMENT
COMMENT Groups of keywords to describe each column of the binary extension
COMMENT
TFORM1  =                nC / Dimension and data type of first field
TTYPE1  = 'name1    '      / Label of first field
TUNIT1  = 'units1   '      / Data units of first field (optional)
TLMIN1  =           minval1 / Minimum field value (optional)
TLMAX1  =           maxval1 / Maximum field value (optional)
.
.
TFORMm  =                nC / Dimension and data type of m'th field.
TTYPEm  = 'namem    '      / Label of m'th field
TUNITm  = 'unitsm   '      / Data units of m'th field (optional)
TLMINm  =           minvalm / Minimum field value (optional)
TLMAXm  =           maxvalm / Maximum field value (optional)
END
```

followed by padding sufficient to make the binary table header a multiple of 36 lines (2880 bytes)

FITS binary table contents

(*size* x *rows*) bytes of binary data

followed by padding sufficient to make the length of the binary table a multiple of 2880 bytes

4.4.2 Parameter Block Files (*_pbk0.fits)

The instrument configuration for each science run will be described by a Parameter Block File, either for Timed Exposure Mode (Table 6) or Continuous Clocking Mode (Table 7). Most of the mode parameters are defined in the keyword section. The binary table contains a row for each FEP that was active during the science run. Note that it is possible, but not usual, for more than one FEP to process data from the *same* CCD.

Note that here, as elsewhere in Level 0 data products, "native hex" keywords are written as long integers, *except* in the case of the GRADEMA# keywords, which appear as hex strings.

Since parameter block files are produced once per Science Run, they are assigned filenames based on `runStartTime`, and `TSTART` and `TSTOP` are based on `runStartTime` and `runStartTime` + `number_of_exposures` * `EXPTIME`, respectively. In the case of a bias-only Science Run, however, `TSTART` is based on `biasStartTime` and `TSTOP = TSTART`. Bias-only SRs are flagged by a `scienceReport` packet `terminationCode` of 2 (`SMTERM_BIASDONE`).

Table 6: Timed Exposure Parameter Block File

Additional FITS Keyword Header Items
PBLOCK = 123456789 / Parameter Block Identifier
WIND_ID = 123456789 / Window block Identifier
FEP_MODE= 2 / 0:Raw; 1:Histogram; 2:3x3; 3:5x5; 4:15 TBD
BEP_MODE= 1 / 0:Faint; 1:Faint Bias; 2:Graded; 3:EvHist; 4:15 TBD
SUM_2X2 = 0 / On-chip summing. 0:None; 1:Sum 2x2
NOBADPIX= 1 / Disable bad pixel map. 0:Use map; 1:Ignore map
NOBADCOL= 1 / Disable bad column map. 0:Use map; 1:Ignore mp
BIAS_CAL= 1 / Enable bias calibration. 0:Don't compute; 1:Comp
SENDBIAS= 0 / Telemeter bias data. 0:Don't send; 1: Send
STARTROW= 0 / Index of first row to clock out CCDs
ROWCNT = 1023 / One less than the number of rows to clock out
OCLKPAIR= 8 / Number of pairs of overclock pixels per output
ORC_MODE= 0 / Output register clocking mode
EXPTIMEA= 35 / Commanded primary exp duration, units of 1/10s
EXPTIMEB= 0 / Commanded secondary exp duration, units of 1/10s
DTYCYCLE= 0 / Number of Secondary exposures per Primary
PHAMIN = 0 / Minimum acceptable pulse height
PHARANGE= -1 / Range of accepted pulse heights
GRADEMA1='FFFFFFFF' / Hex bit pattern of accepted grade flags
GRADEMA2='FFFFFFFF' / Hex bit pattern of accepted grade flags
GRADEMA3='FFFFFFFF' / Hex bit pattern of accepted grade flags
GRADEMA4='FFFFFFFF' / Hex bit pattern of accepted grade flags
GRADEMA5='FFFFFFFF' / Hex bit pattern of accepted grade flags
GRADEMA6='FFFFFFFF' / Hex bit pattern of accepted grade flags
GRADEMA7='FFFFFFFF' / Hex bit pattern of accepted grade flags
GRADEMA8='FFFFFFFF' / Hex bit pattern of accepted grade flags
HISTOCNT= 1 / Number of exposures per histogram
RCMPSLOT= 0 / Slot identifier of raw-mode compression table
EXP_SKIP= 30 / Number of exposure frames to skip at run start
DEALOAD = 0 / If not zero, pointer to DEA Load in RAM
FEPLOAD = 0 / If not zero, pointer to FEP Load in RAM

FITS binary table contents (one entry per active FEP)					
Field	**TTYPE**	**TUNIT**	**TFORM**	**TLMAX[a]**	**Comment**
1	CCD_ID	n/a	1I	9	CCD ID
2	FEP_ID	n/a	1I	5	Front End Processor ID
3	VIDRESP	n/a	1I	1	CCD video chain response selection, 0 for 1:1
4	EVT_THR	adu	4I	4095	Event thresholds for nodes A-D (TLMIN=-4096)
5	SPL_THR	adu	4I	4095	Split thresholds for output nodes A-D
6	BCMPSLOT	n/a	1I	255	Slot identifier for bias map compression tab
7	BIASALG	n/a	1I	255	Bias algorithm id. 1:whole frame; 2:strip
8	BIASARG0	n/a	1I	32767	Bias argument 0 (TLMIN=-32768)
9	BIASARG1	n/a	1I	32767	Bias argument 1 (TLMIN=-32768)
10	BIASARG2	n/a	1I	32767	Bias argument 2 (TLMIN=-32768)
11	BIASARG3	n/a	1I	32767	Bias argument 3 (TLMIN=-32768)
12	BIASARG4	n/a	1I	32767	Bias argument 4 (TLMIN=-32768)
13	VID_OFF	n/a	4I	4095	Video offsets for CCD output nodes A-D

a. TLMIN is zero, except where noted.

Table 7: Continuous Clocking Parameter Block File

Additional FITS Keyword Header Items

```
PBLOCK  =       123456789 / Parameter Block Identifier
WIND_ID =       123456789 / Window block Identifier
FEP_MODE=               2 / 0:Raw; 1:1x3; 2:3x3; 3:15 TBD
BEP_MODE=               1 / 0:Faint; 1:Graded; 2:15 TBD
NOBADCOL=               1 / 0:Use bad CC column map; 1:Ignore bad column map
BIAS_CAL=               1 / 0:Don't recompute bias maps; 1:Recompute maps
SENDBIAS=               0 / 0:Don't Telemeter bias maps; 1: Telemeter them
SUMROW  =               0 / Number of CCD rows to sum (powers of 2)
SUMCOL  =               0 / Number of CCD columns to sum (powers of 2)
OCLKPAIR=               8 / Number of pairs of overclock pixels per output
ORC_MODE=               0 / Output register clocking mode
PHAMIN  =               0 / Minimum acceptable pulse height
PHARANGE=              -1 / Range of accepted pulse heights
GRADEMAP='FFFF'           / Hex bit pattern of accepted grade flags
RCMPSLOT=               0 / Slot identifier of raw-mode compression table
EXP_SKIP=              30 / Number of exposure frames to skip at run start
DEALOAD =               0 / If not zero, pointer to DEA Load in RAM
FEPLOAD =               0 / If not zero, pointer to FEP Load in RAM
```

FITS binary table contents (one entry per active FEP)					
Field	**TTYPE**	**TUNIT**	**TFORM**	**TLMAX[a]**	**Comment**
1	CCD_ID	n/a	1I	9	CCD ID
2	FEP_ID	n/a	1I	5	Front End Processor ID
3	VIDRESP	n/a	1I	1	CCD video chain response selection, 0 for 1:1
4	EVT_THR	adu	4I	4095	Event thresholds for nodes A-D (TLMIN=-4096)

FITS binary table contents (one entry per active FEP) (Continued)					
Field	**TTYPE**	**TUNIT**	**TFORM**	**TLMAX[a]**	**Comment**
5	SPL_THR	adu	4I	4095	Split thresholds for output nodes A-D
6	BIASALG	n/a	1I	255	Bias algorithm id. 1:whole frame; 2:strip
7	BIASREJ	n/a	1U	65535	Bias algorithm parameter
8	VID_OFF	n/a	4I	4095	Video offsets for CCD output nodes A-D

a. TLMIN is zero, except where noted.

4.4.3 Window Block Files (*_win0.fits)

The instrument configuration may be further qualified by a set of window filters. Each row of the binary table describes a single window, up to the maximum number of 36. In Timed-Exposure Mode, the windows are two-dimensional (Table 8). In Continuous Clocking Mode, they are one-dimensional (Table 9).

Since window block files are produced once per Science Run, they are assigned filenames based on `runStartTime`, and `TSTART` and `TSTOP` are based on `runStartTime` and `runStartTime` + `number_of_exposures` * `EXPTIME`, respectively. In the case of a bias-only Science Run, however, `TSTART` is based on `biasStartTime` and `TSTOP = TSTART`.

Table 8: 2-Dimensional Window Block File

Additional FITS Keyword Header Items					
`WIND_ID = 123456789 / Window block Identifier`					
FITS binary table contents (one entry per window)					
#	**TTYPE**	**TUNIT**	**TFORM**	**TLMAX**	**Comment**
1	CCD_ID	n/a	1I	9	CCD ID
2	LL_CCDX	n/a	1I	1023	Chip lower left corner x value (CCD column)
3	LL_CCDY	n/a	1I	1023	Chip lower left corner y value (CCD row)
4	CCDCOL	n/a	1I	1023	Number of CCD columns (minus 1) covered by window
5	CCDROW	n/a	1I	1023	Number of CCD rows (minus 1) covered by window
6	SAMP_CYC	n/a	1I	255	Event sampling: 0=reject all, 1= accept all, 2=accept every other, 3=accept every 3rd...
7	PHAMIN	adu	1I	4095	Minimum event amplitude accepted by window
8	PHARANGE	adu	1U	65535	Range of event amplitudes accepted by window

Table 9: 1-Dimensional Window Block File

Additional FITS Keyword Header Items					
`WIND_ID = 123456789 / Window block Identifier`					
FITS binary table contents (one entry per window)					
#	**TTYPE**	**TUNIT**	**TFORM**	**TLMAX**	**Comment**
1	CCD_ID	n/a	1I	9	CCD ID
2	LL_CCDX	n/a	1I	1023	Chip lower left corner x value (CCD column)
3	CCDCOL	n/a	1I	1023	Number of CCD columns (minus 1) covered by window
4	SAMP_CYC	n/a	1I	255	Event sampling: 0=reject all, 1= accept all, 2=accept every other, 3=accept every 3rd...
5	PHAMIN	adu	1I	4095	Minimum event amplitude accepted by window
6	PHARANGE	adu	1I	24570	Range of event amplitudes accepted by window

4.4.4 Exposure Record Files (*_f_exr0.fits)

An Exposure Records file (Table 10) is created for each FEP that generates exposure packets in any of the event-finding modes of ACIS (i.e., TE faint, TE faint w/ bias, TE very faint, TE graded, CC faint, CC 3x3, CC graded). This file contains a binary table with one row for each exposure[1]. The exposure counters (EXPNO) will be in ascending order but, since the FEP will skip exposures when it is incapable of processing the incoming events fast enough, some exposures may be missing.

Exposure Record files are produced once per Science Run; they are assigned filenames based on runStartTime, and TSTART and TSTOP are based on runStartTime + first_reported_exposure * EXPTIME and runStartTime + number_of_exposures * EXPTIME, respectively.

Table 10: Exposure Records File

Additional FITS Keyword Header Items

```
RUNSTART=          3924313546 / Science Run Start in units of BEP clock
PBLOCK  =           123456789 / Parameter Block Identifier
WIND_ID =           123456789 / Window block Identifier
BIASTART=          3895671628 / Bias Run Start in units of BEP ticks
BIAS_ID =           123456790 / PBLOCK for last bias cal
FEP_ID  =                   2 / Front End Processor ID: 0-5
CCD_ID  =                   1 / CCD id: 0 - 9
TIMEDEL =               3.330 / Inferred duration of 1 complete exp cycle (s)
TIMEDELA=               3.330 / Inferred duration of primary exposure (s)
TIMEDELB=                  0. / Inferred duration of each secondary exp. (s)
```

FITS binary table contents (one entry per CCD exposure)

#	TTYPE	TUNIT	TFORM	TLMAX[a]	Comment
1	TIME	s	1D	n/a	S/C TT corresponding to mid-exposure
2	EXPTIME	s[b]	1I	32767	Commanded duration of exposure (TE), or row readout time (CC)
3	BEPSTAMP	n/a	1V	$2^{32}-1$	BEP Time-tag at start of exposure; DERIVED
4	FEPSTAMP	n/a	1J	$2^{25}-1$	FEP Time-tag at start of exposure; telemetered
5	EXPNO	n/a	1J	$2^{31}-1$	exposure number since start of science run
6	EVTSENT	n/a	1J	$2^{31}-1$	number of events sent in data records
7	THR_PIX	n/a	1J	2^{20}	pixels above respective threshold level
8	DROP_AMP	n/a	1J	$2^{31}-1$	# discarded events due to corrected amplitude
9	DROP_POS	n/a	1J	$2^{31}-1$	# discarded events due to CCD position
10	DROP_GRD	n/a	1J	$2^{31}-1$	# discarded events due to grade code
11	BERR_SUM	n/a	1J	$2^{31}-1$	# pixel bias errors so far in science run
12	DELTOCLK	adu	4I	4095	output node delta overclock values (TLMIN=-4096)

a. TLMIN is zero, except where noted.

1. For Continuous Clocking mode, an exposure is defined as a group of 512 rows of pixels, irrespective of the current value of the SUMROW patrameter in Table 7.

b. TSCAL = 0.1 for timed exposure mode; TSCAL = 0.00001 for continuous clocking.

4.4.5 Bias Error Files (*_f_berr0.fits)

When a FEP detects a parity error in its bias memory (most likely the result of a charged particle event), it writes a `biasError` telemetry packet. These are written to Bias Error files (Table 11), one for each FEP that reported at least one such error during that particular science run.

Since bias error files are produced once per Science Run, they are assigned filenames based on `runStartTime`, and `TSTART` and `TSTOP` are based on `runStartTime` and `runStartTime` + `number_of_exposures` * `EXPTIME`, respectively.

Table 11: Bias Error File

Additional FITS Keyword Header Items					
RUNSTART= 3924313546 / Science Run Start in units of BEP clock FEP_ID = 2 / Front End Processor ID: 0-5 CCD_ID = 1 / CCD id: 0 - 9					
FITS binary table contents (one entry per bias error)					
#	**TTYPE**	**TUNIT**	**TFORM**	**TLMAX[a]**	**Comment**
1	TIME	s	1D	n/a	S/C TT corresponding to mid-exposure
2	EXPNO	n/a	1J	$2^{31}-1$	Exposure number since start of science run
3	CCDX	n/a	1I	1023	CCD column position of bad pixel within bias map
4	CCDY	n/a	1I	1023	CCD row position of bad pixel within bias map
5	BIAS	adu	1I	4095	Bias map pixel value which produced the error and which will be replaced by 4094 in the bias map

a. TLMIN=0 unless otherwise noted.

4.4.6 Timed-Exposure Event Files (*_f_evt0.fits)

In each timed-exposure mode, all X-ray events from a given FEP are written to one of the event files described in Table 12 through Table 15. The EXPNO field serves as an index into the accompanying exposure record file. The CYCLE keyword describes whether the event file contains events from primary exposures ('P'), secondary exposures ('S'), or both ('B'). At Level 0, CYCLE will be either 'P' or 'B' depending on the value of the DTYCYCLE keyword in the associated parameter block file. If DTYCYCLE is non-zero, then CYCLE='B'; if DTYCYCLE=0 then CYCLE='P'. Subsequent collation of events (following Level 0) may change this value. Note, in particular, that a value of CYCLE='S' can only be assigned subsequent to Level 0, when exposure records and events are "collated" into separate files according to their position within the alternating exposure time duty cycle.

Event files are produced once per Science Run; they are assigned filenames based on runStartTime, and TSTART and TSTOP are based on runStartTime + first_reported_exposure * EXPTIME and runStartTime + number_of_exposures * EXPTIME, respectively.

Table 12: TE Faint Event Data File

Additional FITS Keyword Header Items					
FEP_ID = 2 / Front End Processor ID: 0-5 CCD_ID = 1 / CCD id: 0 - 9 CYCLE = 'B' / events are from which exps? P[rim]/S[econd]/B[oth] TIMEDEL = 3.330 / Inferred duration of 1 complete exp cycle (s) TIMEDELA= 3.330 / Inferred duration of primary exposure (s) TIMEDELB= 0. / Inferred duration of each secondary exp. (s)					
FITS binary table contents (one entry per event)					
#	**TTYPE**	**TUNIT**	**TFORM**	**TLMAX[a]**	**Comment**
1	TIME	s	1D	n/a	S/C TT corresponding to mid-exposure
2	EXPNO	n/a	1J	$2^{31}-1$	Exposure number since start of science run
3	CCDX	n/a	1I	1022	CCD column position of center pixel of event (TLMIN=1)
4	CCDY	n/a	1I	1022	CCD row position of center pixel of event (TLMIN=1)
5	RAW_PHAS	adu	9I	4095	3x3 array of raw pixel pulse heights

a. TLMIN=0 unless otherwise noted.

Table 13: TE Faint-with-bias Event Data File

Additional FITS Keyword Header Items

```
FEP_ID  =                    2 / Front End Processor ID: 0-5
CCD_ID  =                    1 / CCD id: 0 - 9
CYCLE   = 'B'        / events are from which exps? P[rim]/S[econd]/B[oth]
INITOCLA=                  123 / Average initial overclock for node A (ADUs)
INITOCLB=                  123 / Average initial overclock for node B (ADUs)
INITOCLC=                  123 / Average initial overclock for node C (ADUs)
INITOCLD=                  123 / Average initial overclock for node D (ADUs)
TIMEDEL =                3.330 / Inferred duration of 1 complete exp cycle (s)
TIMEDELA=                3.330 / Inferred duration of primary exposure (s)
TIMEDELB=                   0. / Inferred duration of each secondary exp. (s)
```

FITS binary table contents (one entry per event)

#	TTYPE	TUNIT	TFORM	TLMAX[a]	Comment
1	TIME	s	1D	n/a	S/C TT corresponding to mid-exposure
2	EXPNO	n/a	1J	$2^{31}-1$	Exposure number since start of science run
3	CCDX	n/a	1I	1022	CCD column position of center pixel of event (TLMIN=1)
4	CCDY	n/a	1I	1022	CCD row position of center pixel of event (TLMIN=1)
5	RAW_PHAS	adu	9I	4095	3x3 array of raw pixel pulse heights
6	BIAS	adu	9I	4095	3x3 array of pixel bias map values

a. TLMIN=0 unless otherwise noted.

Table 14: TE Graded Event Data File

Additional FITS Keyword Header Items

```
FEP_ID  =                    2 / Front End Processor ID: 0-5
CCD_ID  =                    1 / CCD id: 0 - 9
CYCLE   = 'B'        / events are from which exps? P[rim]/S[econd]/B[oth]
TIMEDEL =                3.330 / Inferred duration of 1 complete exp cycle (s)
TIMEDELA=                3.330 / Inferred duration of primary exposure (s)
TIMEDELB=                   0. / Inferred duration of each secondary exp. (s)
```

FITS binary table contents (one entry per CCD exposure frame)

FITS binary table contents (one entry per event)

#	TTYPE	TUNIT	TFORM	TLMAX[a]	Comment
1	TIME	s	1D	n/a	S/C TT corresponding to mid-exposure
2	EXPNO	n/a	1J	$2^{31}-1$	Exposure number since start of science run
3	CCDX	n/a	1I	1022	CCD column position of center pixel of event (TLMIN=1)

FITS binary table contents (one entry per event) (Continued)					
#	**TTYPE**	**TUNIT**	**TFORM**	**TLMAX[a]**	**Comment**
4	CCDY	n/a	1I	1022	CCD row position of center pixel of event (TLMIN=1)
5	PHA	adu	1J	73710	Bias-corrected pulse-height of the 3x3 event
6	FLTGRADE	n/a	1I	255	Grade code of the event
7	CORN_PHA	adu	1I	4095	Mean corrected pulse heights of corner pixels (TLMIN=-4096)

a. TLMIN is zero, except where noted.

Table 15: TE Very Faint Event Data File

Additional FITS Keyword Header Items

```
FEP_ID  =                    2 / Front End Processor ID: 0-5
CCD_ID  =                    1 / CCD id: 0 - 9
CYCLE   = 'B'         / events are from which exps? P[rim]/S[econd]/B[oth]
TIMEDEL =                3.330 / Inferred duration of 1 complete exp cycle (s)
TIMEDELA=                3.330 / Inferred duration of primary exposure (s)
TIMEDELB=                   0. / Inferred duration of each secondary exp. (s)
```

FITS binary table contents (one entry per event)

#	TTYPE	TUNIT	TFORM	TLMAX[a]	Comment
1	TIME	s	1D	n/a	S/C TT corresponding to mid-exposure
2	EXPNO	n/a	1J	$2^{31}-1$	Exposure number since start of science run
3	CCDX	n/a	1I	1022	CCD column position of center pixel of event (TLMIN=1)
4	CCDY	n/a	1I	1022	CCD row position of center pixel of event (TLMIN=1)
5	RAW_PHAS	adu	25I	4095	5x5 array of raw pixel pulse heights

a. TLMIN=0 unless otherwise noted.

4.4.7 Continuous Clocking Event Files (*_f_evt0.fits)

In each continuous-clocking mode, all X-ray events from a given FEP are written to one of the event files described in Tables 16–19, depending on the event telemetry packing format. The EXPNO field serves as an index into the accompanying exposure record file.

Event packets from CC 3x3 modes are distinguished from their TE cousins only by the *formatTag* within the packets, not by a separate packet type. See *dataTeFaint* and *dataTeGraded* packet descriptions in Applicable Document 3.

Event files are produced once per Science Run; they are assigned filenames based on `runStartTime`, and `TSTART` and `TSTOP` are based on `runStartTime + first_reported_exposure * EXPTIME` and `runStartTime + number_of_exposures * EXPTIME`, respectively.

Table 16: CC (1x3) Faint Event Data File

Additional FITS Keyword Header Items					

`FEP_ID = 2 / Front End Processor ID: 0-5`
`CCD_ID = 1 / CCD id: 0 - 9`
`TIMEDEL = 3.330 / Inferred duration of row readout (s)`					

FITS binary table contents (one entry per CCD exposure frame)					
Field	**TTYPE**	**TUNIT**	**TFORM**	**TLMAX[a]**	**Comment**
1	TIME	s	1D	n/a	S/C TT corresponding to row readout
2	EXPNO	n/a	1J	$2^{31}-1$	Exposure number since start of science run
3	TROW	n/a	1I	511	Transfer row counter of center pixel of event
4	CCDX	n/a	1I	1022	CCD column position of center pixel of event (TLMIN=1)
5	RAW_PHAS	adu	3I	4095	1x3 array of raw pixel pulse heights

a. TLMIN=0 unless otherwise noted.

Table 17: CC 3x3 Faint Event Data File

Additional FITS Keyword Header Items					

`FEP_ID = 2 / Front End Processor ID: 0-5`
`CCD_ID = 1 / CCD id: 0 - 9`
`TIMEDEL = 3.330 / Inferred duration of row readout (s)`					

FITS binary table contents (one entry per CCD exposure frame)					
Field	**TTYPE**	**TUNIT**	**TFORM**	**TLMAX[a]**	**Comment**
1	TIME	s	1D	n/a	S/C TT corresponding to row readout
2	EXPNO	n/a	1J	$2^{31}-1$	Exposure number since start of science run
3	TROW	n/a	1I	511	Transfer row counter of center pixel of event
4	CCDX	n/a	1I	1022	CCD column position of center pixel of event (TLMIN=1)
5	RAW_PHAS	adu	9I	4095	3x3 array of raw pixel pulse heights

a. TLMIN=0 unless otherwise noted.

Table 18: CC (1x3) Graded Event Data File

Additional FITS Keyword Header Items					
FEP_ID = 2 / Front End Processor ID: 0-5 CCD_ID = 1 / CCD id: 0 - 9 TIMEDEL = 3.330 / Inferred duration of row readout (s)					
FITS binary table contents (one entry per CCD exposure frame)					
Field	**TTYPE**	**TUNIT**	**TFORM**	**TLMAX[a]**	**Comment**
1	TIME	s	1D	n/a	S/C TT corresponding to row readout
2	EXPNO	n/a	1J	$2^{31}-1$	Exposure number since start of science run
3	TROW	n/a	1I	511	Transfer row counter of center pixel of event
4	CCDX	n/a	1I	1022	CCD column position of center pixel of event (TLMIN=1)
5	PHA	adu	1I	12284	Bias-corrected pulse-height of the 1x3 event
6	FLTGRADE	n/a	1I	3	Grade code of the event

a. TLMIN=0 unless otherwise noted.

Table 19: CC 3x3 Graded Event Data File

Additional FITS Keyword Header Items					
FEP_ID = 2 / Front End Processor ID: 0-5 CCD_ID = 1 / CCD id: 0 - 9 TIMEDEL = 3.330 / Inferred duration of row readout (s)					
FITS binary table contents (one entry per CCD exposure frame)					
Field	**TTYPE**	**TUNIT**	**TFORM**	**TLMAX[a]**	**Comment**
1	TIME	s	1D	n/a	S/C TT corresponding to row readout
2	EXPNO	n/a	1J	$2^{31}-1$	Exposure number since start of science run
3	TROW	n/a	1I	511	Transfer row counter of center pixel of event
4	CCDX	n/a	1I	1022	CCD column position of center pixel of event (TLMIN=1)
5	PHA	adu	1J	73710	Bias-corrected pulse-height of the 3x3 event
6	FLTGRADE	n/a	1I	255	Grade code of the event
7	CORN_PHA	adu	1I	4095	Mean corrected pulse heights of corner pixels (TLMIN=-4096)

a. TLMIN=0 unless otherwise noted.

4.4.8 Science Run Report File (*_srr0.fits)

A Report File accompanies each science run (Table 20). Since science run report files are produced once per Science Run, they are assigned filenames based on `runStartTime`, and `TSTART` and `TSTOP` are based on `runStartTime` and `runStartTime` + `number_of_exposures` * `EXPTIME`, respectively. In the case of a bias-only Science Run, however, TSTART is based on biasStartTime and TSTOP = TSTART. Bias-only SRs are flagged by a `scienceReport` packet `terminationCode` of 2 (`SMTERM_BIASDONE`). For other abnormal termination conditions (e.g. radiation monitor asserted) under which no valid `runStartTime` is available, the timestamp of the minor frame containing the science run report packet is used to assign `TSTART/TSTOP` and hence filename.

Table 20: Science Run Report File

Additional FITS Keyword Header Items
`RUNSTART=  3924313546 / Science Run Start in units of BEP clock`
`BIASTART=  3895671628 / Bias Run Start in units of BEP ticks`
`PBLOCK  =   123456789 / Parameter Block Identifier`
`WIND_ID =   123456789 / Window block Identifier`
`BIAS_ID =   123456790 / PBLOCK for last bias cal`
`EXPTOT  =     335 / max. no. of exps. produced by any *single* FEP`
`EXPSENT =      50 / total number of exposures telemetered`
`BERR_CNT=       0 / number of pixel bias map errors detected`
`DEA_ERRS=       0 / errors detected on DEA Interface Board, 1 flag`
`TERMCODE=       1 / Code indicating the reason for the end of run`
FITS binary table contents (one entry per active FEP)

4.4.9 Science Run Product Summary File (*_srp0.fits)

The science (as opposed to HK) products generated during Level 0 processing of a science run are summarized in a Product Summary File (Table 21), which contains the filename and TSTART/TSTOP times for each product. It is the last file produced by Level 0 decommutation software, upon completion of processing of a Science Run, and hence can be used to flag the availability of products for archiving.

Since Product Summary files are produced once per Science Run, they are assigned filenames based on runStartTime, and TSTART and TSTOP are based on runStartTime and runStartTime + number_of_exposures * EXPTIME, respectively. In the case of a bias-only Science Run, however, TSTART is based on biasStartTime and TSTOP = TSTART.

Table 21: Science Run Product Summary File

Additional FITS Keyword Header Items					
RUNSTART= 3924313546 / Science Run Start in units of BEP clock BIASTART= 3895671628 / Bias Run Start in units of BEP ticks PBLOCK = 123456789 / Parameter Block Identifier WIND_ID = 123456789 / Window block Identifier BIAS_ID = 123456790 / PBLOCK for last bias cal					
FITS binary table contents (one entry per product)					
Field	**TTYPE**	**TUNIT**	**TFORM**	**TLMAX[a]**	**Comment**
1	FILENAME	n/a	40A	n/a	filename of data product
2	TSTART	s	1D	n/a	TSTART of data product
3	TSTOP	s	1D	n/a	TSTOP of data product
4	PRODCONTENT	s	20A	n/a	CONTENT keyword of data product
5	PRODNAME	s	20A	n/a	mneumonic summarizing contents of data product

a. TLMIN=0 unless otherwise noted.

4.4.10 Bias Map Files (*_f_bias0.fits)

The bias map files do not contain FITS binary table extensions. Instead, they use the FITS convention to describe 2-dimensional image arrays. Timed-exposure bias maps (Table 22) will always contain 1024x1024 pixels, and continuous-clocking bias maps (Table 23) will contain 1024x512 pixels. These formats apply even when less than a full CCD is read out (TE sub-array mode), or when pixels are summed on-chip (2x2 summation in TE mode or column and/or row summation in CC mode, as determined from the SUM_2x2 or SUMCOL keywords, respectively). In the latter case, pixels are replicated to produce the proper image format.

"Good" bias map pixel values are in the range 0-4093. Pixels belonging to the current bad-pixel or bad-column lists, and pixels lying outside the area read out in sub-array mode, will be assigned the value PIXEL_BAD (decimal 4095). Pixels that have caused parity errors during a science run before the bias map was copied to the telemetry stream will be assigned the value BIAS_BAD (decimal 4094).

If present in a Science Run, Bias files are assigned filenames based on biasStartTime, and TSTART and TSTOP are both based on biasStartTime + ignored_exposures*EXPTIME.

Table 22: TE Bias Map File

FITS Keyword Header

```
SIMPLE  =                    T / FITS STANDARD
BITPIX  =                   16 / 16-bit image pixels
NAXIS   =                    2 / 2-dimensional image
NAXIS1  =                 1024 / Number of pixels per row
NAXIS2  =                 1024 / Number of rows
EXTEND  =                    T / FITS dataset may include extensions
CTYPE1  = 'CCDX'               / X coordinate system
CTYPE2  = 'CCDY'               / Y coordinate system
CRPIX1  =                    0 / X reference pixel (column)
CRPIX2  =                    0 / Y reference pixel (row)
CRVAL1  =                   0. / reference value
CRVAL2  =                   0. / reference value
CDELT1  =                0.024 / X pixel increment
CDELT2  =                0.024 / Y pixel increment
CUNIT1  =                 'mm' / X pixel unit
CUNIT2  =                 'mm' / Y pixel unit
COMMENT
COMMENT   AXAF FITS TE Bias File: ACIS Level 0
COMMENT
.............Required keywords (see Applicable Document 9):...........
.............Section CC: configuration control keywords..............
.............Section T: timing keywords.............................
.............Section O (short): observation info keywords.............
COMMENT
```

Table 22: TE Bias Map File (Continued)

FITS Keyword Header
COMMENT COMMENT AXAF FITS TE Bias File: Special ACIS Keywords COMMENT PBLOCK = 123456789 / ParamBlock ID of ParamBlock that generated bias READMODE= 'TIMED ' / CCD exposure mode DATAMODE= 'FAINT ' / CCD telemetry mode RUN_ID = 1 / Science run index FSW_VERS= 0 / ACIS flight software version number STARTBEP= 0 / BEP timer value at TSTART FEP_ID = 0 / FEP id: 0 - 5 CCD_ID = 7 / CCD id: 0 - 9 STARTROW= 0 / Index of first CCD row telemetered ROWCNT = 1023 / Number of CCD rows telemetered CCDNODES= 4 / Number of CCD output nodes ORC_MODE= 0 / CCD readout mode SUM2X2 = 0 / 2x2 pixel summation: 1 (YES) or 0 (NO) DEAGAIN = 0 / Video gain setting: 0:high, 1:low BIASALG = 1 / Bias algorithm parameter BIASARG0= 5 / Bias argument 1 BIASARG1= 16 / Bias argument 2 BIASARG2= 0 / Bias argument 3 BIASARG3= 26 / Bias argument 4 BIASARG4= 20 / Bias argument 5 INITOCLA= 794 / Average initial overclock for node A INITOCLB= 553 / Average initial overclock for node B INITOCLC= 700 / Average initial overclock for node C INITOCLD= 655 / Average initial overclock for node D END
followed by padding sufficient to make the header a multiple of 36 lines (2880 bytes)
FITS image array
1024 x 1024 image pixels—16-bit signed integers

Table 23: CC Bias Map File

FITS Keyword Header

```
SIMPLE  =                    T / FITS STANDARD
BITPIX  =                   16 / 16-bit image pixels
NAXIS   =                    2 / 2-dimensional image
NAXIS1  =                 1024 / Number of pixels per row
NAXIS2  =                  512 / Number of rows
CTYPE1  = 'CCDX'               / X coordinate system
CTYPE2  = 'TROW'               / Y coordinate system
CRPIX1  =                    0 / X reference pixel (column)
CRPIX2  =                    0 / Y reference pixel (row)
CRVAL1  =                   0. / reference value
CRVAL2  =                   0. / reference value
CDELT1  =                 0.024 / X pixel increment
CDELT2  =                 0.024 / Y pixel increment
CUNIT1  =                  'mm' / X pixel unit
CUNIT2  =                  'mm' / Y pixel unit
COMMENT
COMMENT   AXAF FITS CC Bias File: ACIS Level 0
COMMENT
COMMENT
.............Required keywords (see Applicable Document 9):...........
.............Section M: mandatory FITS keywords for HDU type..........
.............Section CC: configuration control keywords..............
.............Section T: timing keywords..............................
.............Section O (short): observation info keywords.............
COMMENT
COMMENT   AXAF FITS CC Bias File: Special ACIS Keywords
COMMENT
READMODE= 'CONTINUOUS'         / CCD exposure mode
DATAMODE= 'CC_FAINT'           / CCD telemetry mode
RUN_ID  =                    1 / Science run index
FSW_VERS=                    0 / ACIS flight software version number
STARTBEP=                    0 / BEP timer value at TSTART
FEP_ID  =                    0 / FEP id: 0 - 5
CCD_ID  =                    7 / CCD id: 0 - 9
CCDNODES=                    4 / Number of CCD output nodes
SUMROW  =                    0 / Number of CCD rows to sum (powers of 2)
SUMCOL  =                    0 / Number of CCD columns to sum (powers of 2)
ORC_MODE=                    0 / CCD readout mode
DEAGAIN =                    0 / Video gain setting: 0:high, 1:low
BIASALG =                    1 / Bias algorithm id. 1:whole frame; 2:strip
BIASREJ =                    1 / Bias rejection parameter
INITOCLA=                  794 / Average initial overclock for node A
INITOCLB=                  553 / Average initial overclock for node B
INITOCLC=                  700 / Average initial overclock for node C
INITOCLD=                  655 / Average initial overclock for node D
END
```

followed by padding sufficient to make the header a multiple of 36 lines (2880 bytes)

FITS image array

Table 23: CC Bias Map File (Continued)

FITS Keyword Header
1024 X 512 image pixels—16-bit signed integers

4.4.11 Raw Mode (Image) Files (*_*f*E*eee*_img0.fits)

In either TE or CC modes, raw pixel data can be telemetered via the “raw” telemetry packing format. Table 24 and Table 25 describe the L0 data products corresponding to these formats. In CC mode, one image is written per 512-row block or ‘frame’. The ‘*eee*’ in the filename indicates the exposure number of the image. Timed-exposure raw images (Table 24) will always contain (1024+(OCLKPAIR*8))x1024 pixels, and continuous-clocking raw images (Table 25) will contain (1024+(OCLKPAIR*8))x512 pixels. These formats apply even when less than a full CCD is read out (TE sub-array mode), or when pixels are summed on-chip (2x2 summation in TE mode or column and/or row summation in CC mode, as determined from the SUM_2x2 or SUMCOL keywords, respectively). In the latter case, pixels are replicated to produce the proper image format.

Several Image files may be produced per Science Run. They are assigned filenames based on runStartTime, and TSTART and TSTOP are based on runStartTime + exposure_number * EXPTIME and runStartTime + (exposure_number + 1) * EXPTIME, respectively.

.

Table 24: TE Image File

FITS Keyword Header

```
SIMPLE  =                    T / FITS STANDARD
BITPIX  =                   16 / 16-bit image pixels
NAXIS   =                    2 / 2-dimensional image
NAXIS1  =                    m / Number of pixels per row
                               / (= 1024 + 2*OCLKPAIR*CCDNODES)
NAXIS2  =                 1024 / Number of rows
EXTEND  =                    T / FITS file may contain extensions
CTYPE1  = 'CCDX'               / coordinate system
CTYPE2  = 'CCDY'               / coordinate system
CRPIX1  =                    0 / X reference pixel (column)
CRPIX2  =                    0 / Y reference pixel (row)
CRVAL1  =                   0. / reference value
CRVAL2  =                   0. / reference value
CDELT1  =                0.024 / X pixel increment
CDELT2  =                0.024 / Y pixel increment
CUNIT1  =                 'mm' / X pixel unit
CUNIT2  =                 'mm' / Y pixel unit
COMMENT
COMMENT   AXAF FITS TE Image File: ACIS Level 0
COMMENT
.............Required keywords (see Applicable Document 9):...........
.............Section CC: configuration control keywords..............
.............Section T: timing keywords.............................
.............Section O (short): observation info keywords.............
COMMENT
COMMENT   AXAF FITS TE Image File: Special ACIS Keywords
COMMENT
READMODE= 'TIMED   '           / CCD exposure mode
DATAMODE= 'RAW     '           / CCD telemetry mode
RUN_ID  =                    1 / Science run index
FSW_VERS=                    0 / ACIS flight software version number
STARTBEP=                    0 / BEP timer value at TSTART
STOPBEP =                    0 / BEP timer value at TSTOP
RUNSTART=           3924313546 / Science Run Start in units of BEP clock
PBLOCK  =            123456789 / Parameter Block Identifier
WIND_ID =            123456789 / Window block Identifier
FEPSTAMP=            123456789 / FEP timestamp at beginning of frame mark
EXPNO   =                    3 / exposure number
FEP_ID  =                    0 / FEP id: 0 - 5
CCD_ID  =                    7 / CCD id: 0 - 9
STARTROW=                    0 / Index of first CCD row telemetered
ROWCNT  =                 1024 / no. of CCD rows telemetered
CCDNODES=                    4 / Number of CCD output nodes
OCLKPAIR=                    8 / No. of pairs of overclock pixels per node
ORC_MODE=                    0 / CCD readout mode
SUM2X2  =                    0 / Pixel summation: YES or NO
DEAGAIN =                    0 / Video gain setting: 0:high, 1:low
END
```

Table 24: TE Image File (Continued)

FITS Keyword Header
followed by padding sufficient to make the header a multiple of 36 lines (2880 bytes)
FITS image array
1024 x 1024 image pixels—16-bit signed integers

Table 25: CC Image File

FITS Keyword Header

```
SIMPLE  =                    T / FITS STANDARD
BITPIX  =                   16 / 16-bit image pixels
NAXIS   =                    2 / 2-dimensional image
NAXIS1  =                    m / Number of pixels per row
                               / (= 1024 + 2*OCLKPAIR*CCDNODES)
NAXIS2  =                  512 / Number of rows
EXTEND  =                    T / FITS file may contain extensions
CTYPE1  = 'CCDX'               / X coordinate system
CTYPE2  = 'TROW'               / Y coordinate system
CRPIX1  =                    0 / X reference pixel (column)
CRPIX2  =                    0 / Y reference pixel (row)
CRVAL1  =                   0. / reference value
CRVAL2  =                   0. / reference value
CDELT1  =                0.024 / X pixel increment
CDELT2  =                0.024 / Y pixel increment
CUNIT1  =                 'mm' / X pixel unit
CUNIT2  =                 'mm' / Y pixel unit
COMMENT
COMMENT   AXAF FITS CC Image File: ACIS Level 0
COMMENT
.............Required keywords (see Applicable Document 9):...........
.............Section CC: configuration control keywords..............
.............Section T: timing keywords.............................
.............Section O (short): observation info keywords.............
COMMENT
COMMENT   AXAF FITS CC Image File: Special ACIS Keywords
COMMENT
READMODE= 'CONTINUOUS'         / CCD exposure mode
DATAMODE= 'CC_RAW  '           / CCD telemetry mode
RUN_ID  =                    1 / Science run index
FSW_VERS=                    0 / ACIS flight software version number
STARTBEP=                    0 / BEP timer value at TSTART
STOPBEP=                     0 / BEP timer value at TSTOP
RUNSTART=         3924313546 / Science Run Start in units of BEP clock
PBLOCK  =          123456789 / Parameter Block Identifier
WIND_ID =          123456789 / Window block Identifier
FEPSTAMP=          123456789 / FEP timestamp at beginning of frame mark
EXPNO   =                    3 / exposure number
FEP_ID  =                    0 / FEP id: 0 - 5
CCD_ID  =                    7 / CCD id: 0 - 9
CCDNODES=                    4 / Number of CCD output nodes
OCLKPAIR=                    8 / No. of pairs of overclock pixels per node
SUMROW  =                    0 / Number of CCD rows to sum (powers of 2)
SUMCOL  =                    0 / Number of CCD columns to sum (powers of 2)
ORC_MODE=                    0 / CCD readout mode
DEAGAIN =                    0 / Video gain setting: 0:high, 1:low
END
```

followed by padding sufficient to make the header a multiple of 36 lines (2880 bytes)

FITS image array

Table 25: CC Image File (Continued)

FITS Keyword Header
1024 X 512 image pixels—16-bit signed integers

4.4.12 Histogram Files (*_*f*N*n*E*eee*_hist0.fits)

In TE histogram or event histogram modes, respectively, the number of pixels vs. pixel value (ADU) or the number of events vs. event amplitude (also in ADU) is compiled and the result telemetered, as described in Applicable Document 1. The L0 format for a TE mode histogram is shown in Table 26. In the filename, the '_*f*' indexes the FEP and the '*n*' the node which produced the histogram, while the '*eee*' indicates the first exposure used to calculate the histogram (and thus is equivalent to STARTEXP).

Several Histogram files may be produced per Science Run. They are assigned filenames based on runStartTime, and TSTART and TSTOP are based on runStartTime + STARTEXP * EXPTIME and runStartTime + (ENDEXP + 1) * EXPTIME, respectively.

Table 26: Histogram File

Additional FITS Keyword Header Items
RUNSTART= 3924313546 / Science Run Start in units of BEP clock PBLOCK = 123456789 / Parameter Block Identifier FEP_ID = 2 / Front End Processor ID: 0-5 CCD_ID = 1 / CCD id: 0 - 9 NODE_ID = 0 / CCD node id: 0 - 3 STARTEXP= 2 / Starting exposure used for histogram ENDEXP= 31 / Ending exposure used for histogram EXPCOUNT= 30 / # of exposures used to produce histogram HISTTYPE='PIXEL' / type of histogram: PIXEL or EVENT FEPSTAMP= 123456789 / FEP timestamp of 1st exposure MINOCLK = 10 / minimum overclock pixel value MAXOCLK = 20 / maximum overclock pixel value MEANOCLK= 15 / mean of overclock pixel values VAROCLKL= 0 / varianceOverclockLow VAROCLKH= 0 / varianceOverclockHigh

FITS binary table contents (one entry per histogram bin)					
#	TTYPE	TUNIT	TFORM	TLMAX[a]	Comment
1	BIN	bin	1I	4095	ADU bin
2	COUNTS	count	1J	$2^{31}-1$	Number of pixels reportingADU value of given bin

a. TLMIN=0 unless otherwise noted.

4.4.13 DEA Housekeeping Files (*_hkp0.fits)

All housekeeping telemetry received from the DEA analog boards and from the DEA interface controllers shall be decommutated by the Level 0 processing system and written to DEA Housekeeping (HK) Files (Table 27). There are two fundamental types of ACIS DEA HK queries (see Appendix B-6): DEA interface control HK and DEA analog board HK. These query types can be distinguished by their values of CCD_ID (0-9 for DEA analog board HK; 10 or 11 for DEA interface control HK).

Each file consists of one row per telemetered DEA HK packet. The combination of CCD_ID and QUERY_ID uniquely specifies QUERY_NAME, as determined from Tables B-4 and B-5. Application of the calibration curve appropriate to the given CCD_ID/QUERY_ID combination converts the "raw" value of the DEA housekeeping item, stored in QUERYVAL_TU, to the calibrated HK quantity QUERYVAL.

Table 27: DEA Housekeeping File

Additional FITS Keyword Header Items					
(no additional product-specific header items)					
FITS binary table contents (one entry per DEA HK packet)					
Field	**TTYPE**	**TUNIT**	**TFORM**	**TLMAX[a]**	**Comment**
1	TIME	s	1D	n/a	TT time of minor frame containing HK packet
2	DEABLKID	n/a	1V	$2^{32}-1$	DEA parameter block identifier
3	CMD_ID	n/a	1V	$2^{32}-1$	Command ID which generated DEA HK
4	BEPCOUNT	n/a	1V	$2^{32}-1$	BEP timer tick interrupt counter value
5	CCD_ID	n/a	1I	11	DEA analog board (0-9) or interface control (10-11)
6	QUERY_ID	n/a	1I	255	DEA query ID
7	QUERY_NAME	n/a	40A	n/a	DEA query name (mnemonic)
8	QUERYVAL_TU	n/a	1U	65535	"raw" value of queried item
9	QUERYVAL	n/a	1E	n/a	calibrated value of queried item

a. TLMIN=0 unless otherwise noted.

4.4.14 System Configuration Table Files (*_sys0.fits)

Should the system configuration table be downlinked to the telemetry stream during (or after) a science run[1], it will be written to a System Configuration file (Table 28). The "SysConfigTable" enumeration is defined in the ACIS IP&CL Release Notes (Applicable Document 3). The numerous analog housekeeping channels are described in Applicable Document 4 (see Table 4 for the SYSSET_DAC series and Table 7 for the SYSSET_CNTL series; the SYSSET_CCD enumerations set bits in the Video control register, described in Table 3). Note that all columns of the binary table contain 16-bit unsigned fields.

Table 28: System Configuration File

Additional FITS Keyword Header Items

```
BEPCOUNT=          56789 / BEP timer tick interrupt counter value
DEA_PWR =             63 / DEA power indicator flags
FEP_PWR =             63 / FEP power indicator flags
MCLKDSAB=              1 / Master clock disable
FP_TEMP =              0 / Focal plane temperature
BAKETEMP=              0 / Bakeout temperature
BAKEENAB=              0 / Bakeout enable flag
LED_ENAB=              0 / LED enable flag
HHKPADDR=              0 / Hold housekeeping address
SIG_SEL =              0 / Signal path select
CCLKDSAB=              0 / COmmand clock disable flag
DCLKDSAB=              0 / Data clock disable flag
RELSET_0=              0 / Relay set 0
RELSET_1=              0 / Relay set 1
RELSET_2=              0 / Relay set 2
RELSET_3=              0 / Relay set 3
RELSET_4=              0 / Relay set 4
```

FITS binary table contents — one entry per CCD/DEA

Field	TTYPE	TUNIT	TFORM	TLMIN	TLMAX	Comment
1	CCD_ID	n/a	1I	0	10	CCD Identifier (0-9) to choose the corresponding DEA CCD Controller, or CCD_DESELECT (10) to choose the DEA interface board
2	SEQ_OFF	n/a	1U	0	65535	Sequencer Offset
3	VADC_OFF	n/a	1U	0	65535	Video ADC Offset
4	VCDSABM	n/a	1U	0	65535	Video Channel Disable Mask
5	HHKPADDR	n/a	1U	0	65535	Hold Housekeeping Address
6	BJD_ENAB	n/a	1U	0	65535	Back-Junction Diode Enable
7	HST_DSAB	n/a	1U	0	65535	High-speed tap disable
8	DAC_PIAP	n/a	1U	0	65535	Image Array Parallel +
9	DACPIAMP	n/a	1U	0	65535	Image Array Parallel -+
10	DAC_PIAM	n/a	1U	0	65535	Image Array Parallel -

1. reported in a `bepReadReply` packet with `formatTag` of `TTAG_DUMP_SYS_CONFIG` (decimal 34).

FITS binary table contents (Continued) — one entry per CCD/DEA						
Field	**TTYPE**	**TUNIT**	**TFORM**	**TLMIN**	**TLMAX**	**Comment**
11	DAC_PFSP	n/a	1U	0	65535	Framestore Parallel +
12	DACPFSMP	n/a	1U	0	65535	Framestore Parallel -+
13	DAC_PFSM	n/a	1U	0	65535	Framestore Parallel -
14	DAC_S_P	n/a	1U	0	65535	Serial Register +
15	DAC_S_M	n/a	1U	0	65535	Serial Register -
16	DAC_R_P	n/a	1U	0	65535	Reset Gate +
17	DAC_R_MP	n/a	1U	0	65535	Reset Gate -+
18	DAC_R_M	n/a	1U	0	65535	Reset Gate -
19	DAC_SCP	n/a	1U	0	65535	Scupper
20	DAC_OG_P	n/a	1U	0	65535	Output Gate +
21	DAC_OG_M	n/a	1U	0	65535	Output Gate -
22	DAC_RD	n/a	1U	0	65535	Reset Diode
23	DAC_DR0	n/a	1U	0	65535	Drain Output (A)
24	DAC_DR1	n/a	1U	0	65535	Drain Output (B)
25	DAC_DR2	n/a	1U	0	65535	Drain Output (C)
26	DAC_DR3	n/a	1U	0	65535	Drain Output (D)
27	DAC_AOFF	n/a	1U	0	65535	A channel offset
28	DAC_BOFF	n/a	1U	0	65535	B channel offset
29	DAC_COFF	n/a	1U	0	65535	C channel offset
30	DAC_DOFF	n/a	1U	0	65535	D channel offset

4.4.15 Software Housekeeping Files (*_swhkp0.fits)

The format of software HK files is given in Table 29.

Table 29: Software Housekeeping File

Additional FITS Keyword Header Items					
BEPCNT_1= 123456789 / BEP interrupt counter value at start of statistics BEPCNT_2= 123456789 / BEP interrupt counter value at end of statistics					
FITS binary table contents (one entry per statistic)					
#	**TTYPE**	**TUNIT**	**TFORM**	**TLMAX[a]**	**Comment**
1	STATID	n/a	1I	32767	ID of statistic being reported
2	COUNT	n/a	1V	$2^{32}-1$	Count of number of occurences of event or condition
3	VALUE	n/a	1V	$2^{32}-1$	Last reported HK value associated w/ event or condition

a. TLMIN=0 unless otherwise noted.

4.4.16 Memory Dump Files (*_t_mem0.fits)

Memory dumps (Table 30) may consist of any of the following (where '_t' denotes the type of dump): bad pixel lists (t=BPX), bad column lists (CC, t=BCC; and TE, t=BCT), software patch list (t=SPL), Huffman decompression tables (t=HUF), parameter slots (t=PAR), or BEP (t=BEP), FEP (t=FEP), PRAM (t=PRM) or SRAM (t=SRM) loads.

Table 30: Memory Dump File

Additional FITS Keyword Header Items					
BEPCOUNT= 3924313546 / BEP timer tick interrupt counter value DUMPTYPE='SRAM_READ_REPLY' / type of memory dump CMD_ID = 123456789 / ID of command which generated dump CCD_ID = 0 / CCD ID (pram/sramReadReply only) FEP_ID = 0 / FEP ID (fepReadReply only)					
FITS binary table contents (one entry per 4-byte field)					
#	**TTYPE**	**TUNIT**	**TFORM**	**TLMAX[a]**	**Comment**
1	CONTENTS	n/a	4B	255	4-byte dump value

a. TLMIN=0 unless otherwise noted.

4.5 VOLUME, SIZE, AND FREQUENCY ESTIMATES

TBD.

Appendix A: IP&CL Fields and MSID Keywords

Table A–1: Traceability between ACIS IP&CL fields and MSID keywords

IP&CL Field Name[a]	Dim[b]	Len[c]	*m*[d]	Keyword[e]	Description
bepStartupMessage	**MSID=SCI_BEP_STARTUP_*m***				**Startup Message emitted by software upon reset of BEP**
bepStartupMessage.bepTickCounter	1	32	0	BEPCOUNT	Back End Timer Tick interrupt counter value at about time packet is posted to telemetry
bepStartupMessage.version	1	32	1	FSW_VERS	Instrument software version number
dataBiasError	**MSID=SCI_BIAS_ERR_*m***				**Bias Error Data Packet from a FEP**
dataBiasError.biasStartTime	1	32	0	BIASTART	Science timestamp counter value at start of the bias computation
dataBiasError.biasParameterId	1	32	1	BIAS_ID	Bias Run's Parameter Block's Identifier field
dataBiasError.ccdId	1	4	2	CCD_ID	Identify which CCD produced the error(s) [§B.1]
dataBiasError.fepId	1	3	3	FEP_ID	Identify which FEP computed the error(s) [§B.4]
dataBiasError.biasErrors[n].row	n	10	4	CCDY	Bias Map row containing the bias error
dataBiasError.biasErrors[n].column	n	10	5	CCDX	Bias Map column containing the bias error
dataBiasError.biasErrors[n].value	n	12	6	BIAS	Bias Map value which produced the error
dataCcBiasMap	**MSID=SCI_CC_BIAS_*m***				**Portion of a Continuous Clocking Bias Map from one FEP**
dataCcBiasMap.biasStartTime	1	32	0	BIASTART	Science timestamp counter value at start of bias computation
dataCcBiasMap.biasParameterId	1	32	1	BIAS_ID	Bias Run's Parameter Block's Identifier field
dataCcBiasMap.ccdId	1	4	2	CCD_ID	Identify which CCD produced the data [§B.1]
dataCcBiasMap.fepId	1	3	3	FEP_ID	Identify which FEP computed the data [§B.4]
dataCcBiasMap.initialOverclocks[4]	4	16	4–7	INITOCLK	Output node initial overclock values added to pixel map values (in Full/Diag Mode, ordered by node [A,B,C,D]. In AC mode, [A,C,x,x] and in BD Mode, [B,D,x,x])
dataCcBiasMap.data[1024]	1024	12[f]	8	n/a	Array of 12-bit bias values, one for each column bias value. Indexed linearly starting from column 0.
dataCcFaint	**MSID=SCI_CC_DAT_FAINT_*m***				**Data Packet, Continuous Clocking, Faint Mode**
dataCcFaint.ccdId	1	4	0	CCD_ID	Identify which CCD produced the data [§B.1]
dataCcFaint.fepId	1	3	1	FEP_ID	Identify which FEP processed the data [§B.4]
dataCcFaint.events[n].transferRow	n	9	3	TROW	Transfer Row counter (relative to start of frame) of center pixel of the event
dataCcFaint.events[n].ccdColumn	n	10	4	CCDX	CCD Column position of center pixel of the event
dataCcFaint.events[n].pulseHeights[3]	3*n	16	5	RAW_PHAS	Array of Raw Pixel Pulse Heights columns -1, 0, 1

Table A–1: Traceability between ACIS IP&CL fields and MSID keywords (Continued)

IP&CL Field Name[a]	Dim[b]	Len[c]	*m*[d]	Keyword[e]	Description
dataCcGraded	**MSID=SCI_CC_DAT_GRADED_*n***				**Data Packet, Continuous Clocking, Graded Mode**
dataCcGraded.ccdId	1	4	0	CCD_ID	Identify which CCD produced the data [§B.1]
dataCcGraded.fepId	1	3	1	FEP_ID	Identify which FEP processed the data [§B.4]
dataCcGraded.events[n].transferRow	n	9	3	TROW	Transfer Row counter (relative to start of frame) of center pixel of the event
dataCcGraded.events[n].ccdColumn	n	10	4	CCDX	CCD Column position of center pixel of the event
dataCcGraded.events[n].eventAmplitude	n	13	5	PHA	Amplitude of the 1x3 Event
dataCcGraded.events[n].gradeCode	n	2	6	FLTGRADE	Graded Code of the event [§B.3]
dataTeBiasMap	**MSID=SCI_TE_BIAS_*m***				**Portion of a Timed Exposure Bias Map from one FEP**
dataTeBiasMap.biasStartTime	1	32	0	BIASTART	Science timestamp counter value at start of bias computation
dataTeBiasMap.biasParameterId	1	32	1	BIAS_ID	Bias Run's Parameter Block's Identifier field
dataTeBiasMap.ccdId	1	4	2	CCD_ID	Identify which CCD produced the data [§B.1]
dataTeBiasMap.fepId	1	3	3	FEP_ID	Identifies which FEP computed and used the bias map [§B.4]
dataTeBiasMap.initialOverclocks[4]	4	16	5–8	INITOCLK	Output node initial overclock values added to pixel map values (In Full/Diag Mode, nodes are ordered as [A,B,C,D]. In AC mode, [A,C,x,x], and in BD mode [B,D,x,x])
dataTeBiasMap.pixelsPerRow	1	10	9	NUMCOLS	Total number of pixels in each bias row minus 1 (i.e. 0 corresponds to 1 pixel)
dataTeBiasMap.rowsPerBias	1	10	10	NUMROWS	Total number of rows in bias image minus 1 (i.e. 0 corresponds to 1 row)
dataTeBiasMap.ccdRow	1	10	11	n/a	CCD Row position of first pixel in data packet
dataTeBiasMap.ccdRowCount	1	10	12	n/a	Number of rows compressed into this data packet minus 1
dataTeBiasMap.compressionTableSlotIndex	1	8	13	BCMPSLOT	Slot index of Compression Table Identifier used to pack data (255 no compression)
dataTeBiasMap.compressionTableIdentifier	1	32	14	HUFF_ID	Identifier stored within Huffman Compression Table used to pack data (0 if no compression)
dataTeBiasMap.pixelCount	1	32	15	n/a	The total number of pixels packed into the packet
dataTeBiasMap.data[n]	n	12[f]	16	n/a	Compressed bias map data values (12-bits/uncompressed value). Indexed by column, starting from 0. Rows sent in reverse order (farthest from Framestore first)
dataTeFaint	**MSID=SCI_TE_DAT_FAINT_*m***				**Data Packet, Timed Exposure, Faint Mode**
dataTeFaint.ccdId	1	4	0	CCD_ID	Identify which CCD produced the data [§B.1]

Table A–1: Traceability between ACIS IP&CL fields and MSID keywords (Continued)

IP&CL Field Name[a]	Dim[b]	Len[c]	*m*[d]	Keyword[e]	Description
dataTeFaint.fepId	1	3	1	FEP_ID	Identify which FEP processed the data [§B.4]
dataTeFaint.events[n].ccdRow	n	10	3	CCDY	CCD Row position of center pixel of the event
dataTeFaint.events[n].ccdColumn	n	10	4	CCDX	CCD Column position of center pixel of the event
dataTeFaint.events[n].pulseHeights[9]	9*n	12	5	RAW_PHAS	Array of Raw Pixel Pulse Heights ((row, column) (-1,-1),(-1,0),(-1,1),(0,-1), ...)
dataTeFaintBias	**MSID=SCI_TE_DAT_FAINTB_*m***				**Data Packet, Timed Exposure, Faint Mode with Bias**
dataTeFaintBias.ccdId	1	4	0	CCD_ID	Identify which CCD produced the data [§B.1]
dataTeFaintBias.fepId	1	3	1	FEP_ID	Identify which FEP processed the data [§B.4]
dataTeFaintBias.events[n].ccdRow	n	10	3	CCDY	CCD Row position of center pixel of the event
dataTeFaintBias.events[n].ccdColumn	n	10	4	CCDX	CCD Column position of center pixel of the event
dataTeFaintBias.events[n].pulseHeights[9]	9*n	12	5	RAW_PHAS	Array of Raw Pixel Pulse Heights ((row, column) (-1,-1),(-1,0),(-1,1),(0,-1), ...)
dataTeFaintBias.events[n].biasValues[9]	9*n	12	6	BIAS	Array of Pixel Bias Map Values ((row, column) (-1,-1),(-1,0),(-1,1),(0,-1), ...)
dataTeGraded	**MSID=SCI_TE_DAT_GRADED_*m***				**Data Packet, Timed Exposure, Graded Mode**
dataTeGraded.ccdId	1	4	0	CCD_ID	Identify which CCD produced the data [§B.1]
dataTeGraded.fepId	1	3	1	FEP_ID	Identify which FEP processed the data [§B.4]
dataTeGraded.events[n].ccdRow	n	10	3	CCDY	CCD Row position of center pixel of the event
dataTeGraded.events[n].ccdColumn	n	10	4	CCDX	CCD Column position of center pixel of the event
dataTeGraded.events[n].eventAmplitude	n	17	5	PHA	Total corrected amplitude of the event
dataTeGraded.events[n].gradeCode	n	8	6	FLTGRADE	Grade code of the event [§B.3]
dataTeGraded.events[n].cornerMean	n	13	7	CORN_PHA	Mean of the corrected pulse height value of corner pixels within the event, rounded to the nearest integer value. If no corner values were valid, this field will contain 4095. If the mean is less than or equal to -4096, the field will be set to -4096
dataTeVeryFaint	**MSID=SCI_TE_DAT_VFAINT_*m***				**Data Packet, Timed Exposure, Faint Mode 5x5**
dataTeVeryFaint.ccdId	1	4	0	CCD_ID	Identify which CCD produced the data [§B.1]
dataTeVeryFaint.fepId	1	3	1	FEP_ID	Identify which FEP processed the data [§B.4]
dataTeVeryFaint.events[n].ccdRow	n	10	3	CCDY	CCD Row position of center pixel of the event
dataTeVeryFaint.events[n].ccdColumn	n	10	4	CCDX	CCD Column position of center pixel of the event (NOTE: Events reported in Column 1 contain garbage in the pixel column 0. Events reported in Column 1022 contain garbage in pixel column 4.)

Table A–1: Traceability between ACIS IP&CL fields and MSID keywords (Continued)

IP&CL Field Name[a]	Dim[b]	Len[c]	*m*[d]	Keyword[e]	Description
dataTeVeryFaint.events[n].pulseHeights[25]	25*n	12	5	RAW_PHAS	Array of Raw Pixel Pulse Heights ((row, column) (-2,-2),(-2,-1),(-2,0),(-2,1),(-2,2),(-1,-2) ...)
deaHousekeepingData	**MSID=SCI_DEA_HOUSE_*m***				**DEA Housekeeping Values**
deaHousekeepingData.deaBlockId	1	32	0	DEA_ID	DEA Parameter Block Identifier
deaHousekeepingData.bepTickCounter	1	32	2	BEPCOUNT	Back End Timer Tick interrupt counter value (0.1 seconds since last BEP reset) at start of data accumulation
deaHousekeepingData.entries[n].ccdId	n	8	3	CCD_ID	CCD Identifier (0-9) to choose the corresponding DEA CCD Controller, or CCD_DESELECT (10) to choose the DEA interface board. [§B.1]
deaHousekeepingData.entries[n].queryId	n	8	4	QUERY_ID	DEA query code sent to board [§B.6]
deaHousekeepingData.entries[n].value	n	16	5	DEA_VAL	DEA Housekeeping value read from identified item. This value will contain 0xffff if the corresponding query to the DEA times out, or if the queried board is not powered on.
exposureCcFaint	**MSID=SCI_CC_REC_FAINT_*m*, SCI_CC_REC_GRADED_*m***				**Exposure Record, Continuous Clocking, Faint and Graded Mode**
exposureCcFaint.runStartTime	1	32	0	RUNSTART	Science timestamp counter value at start of science run
exposureCcFaint.parameterBlockId	1	32	1	PBLOCK	Parameter Block's Identifier field
exposureCcFaint.windowBlockId	1	32	2	WIND_ID	Window List Parameter Block's Identifier field (0xffffffff if none used)
exposureCcFaint.biasStartTime	1	32	3	BIASTART	Science timestamp counter value at start of bias computation
exposureCcFaint.biasParameterId	1	32	4	BIAS_ID	Parameter Block Identifier from most recent bias computation
exposureCcFaint.ccdId	1	4	5	CCD_ID	Identify which CCD produced the data [§B.1]
exposureCcFaint.fepId	1	3	6	FEP_ID	Identify which FEP processed the data [§B.4]
exposureCcFaint.fepTimestamp	1	25	7	FEPSTAMP	FEP Timestamp when FEP received Beginning of Frame mark
exposureCcFaint.exposureNumber	1	32	8	EXPNO	Exposure Number since start of run (of the data just received)
exposureCcFaint.eventsSent	1	32	9	EVTSENT	Number of events telemetered in preceding set of data records
exposureCcFaint.thresholdPixels	1	32	10	THR_PIX	Number of pixels detected above their respective threshold levels
exposureCcFaint.discardEventAmplitude	1	32	11	DROP_AMP	Number of events discarded due to their corrected amplitude
exposureCcFaint.discardWindow	1	32	12	DROP_POS	Number of events discarded due to their CCD position
exposureCcFaint.discardGrade	1	32	13	DROP_GRD	Number of events discarded due to their Grade Code

Table A–1: Traceability between ACIS IP&CL fields and MSID keywords (Continued)

IP&CL Field Name[a]	Dim[b]	Len[c]	*m*[d]	Keyword[e]	Description
exposureCcFaint.deltaOverclocks[4]	4	16[g]	14	DELTOCLK	Output node Delta Overclock values used for the completed exposure (delta = (exposure overclock) - (initial overclock)) (NOTE: In Full/Diag modes, the nodes are indexed as follows [A,B,C,D]. In AC mode, the nodes are [A,C,x,x]. In BD mode, the nodes are [B,D,x,x].
exposureCcFaint.biasParityErrors	1	32	15	BERR_SUM	Total number of pixel bias errors so far in the run
exposureTeFaint	**MSID=SCI_TE_REC_FAINT_*m*, SCI_TE_REC_GRADED_*m*, SCI_TE_REC_VFAINT_*m***				**Exposure Record, Timed Exposure, Faint, Very Faint, & Graded Modes**
exposureTeFaint.runStartTime	1	32	0	RUNSTART	Science timestamp counter value at start of science run
exposureTeFaint.parameterBlockId	1	32	1	PBLOCK	Parameter Block's Identifier field
exposureTeFaint.windowBlockId	1	32	2	WIND_ID	Window List Parameter Block's Identifier field (0xffffffff if none used)
exposureTeFaint.biasStartTime	1	32	3	BIASTART	Science timestamp counter value at start of bias computation
exposureTeFaint.biasParameterId	1	32	4	BIAS_ID	Parameter Block Identifier from most recent bias computation
exposureTeFaint.ccdId	1	4	5	CCD_ID	Identify which CCD produced the data [§B.1]
exposureTeFaint.fepId	1	3	6	FEP_ID	Identify which FEP processed the data [§B.4]
exposureTeFaint.fepTimestamp	1	25	7	FEPSTAMP	Fep Timestamp when FEP received Beginning of Frame mark
exposureTeFaint.exposureNumber	1	32	8	EXPNO	Exposure Number since start of run (of the data just received)
exposureTeFaint.eventsSent	1	32	9	EVTSENT	Number of events telemetered in preceding set of data records
exposureTeFaint.thresholdPixels	1	32	10	THR_PIX	Number of pixels detected above their respective threshold levels
exposureTeFaint.discardEventAmplitude	1	32	11	DROP_AMP	Number of events discarded due to their corrected amplitude
exposureTeFaint.discardWindow	1	32	12	DROP_POS	Number of events discarded due to their CCD position
exposureTeFaint.discardGrade	1	32	13	DROP_GRD	Number of events discarded due to their Grade Code
exposureTeFaint.deltaOverclocks[4]	4	16[g]	14	DELTOCLK	Output node Delta Overclock values used for the completed exposure (delta = (exposure overclock) - (initial overclock)) (NOTE: In Full/Diag modes, the nodes are indexed as follows [A,B,C,D]. In AC mode, the nodes are [A,C,x,x]. In BD mode, the nodes are [B,D,x,x].
exposureTeFaint.biasParityErrors	1	32	15	BERR_SUM	Total number of pixel bias errors so far in the run
exposureTeFaintBias	**MSID=SCI_TE_REC_FAINTB_*m***				**Exposure Record, Timed Exposure, Faint with Bias Mode**
exposureTeFaintBias.runStartTime	1	32	0	RUNSTART	Science timestamp counter value at start of science run
exposureTeFaintBias.parameterBlockId	1	32	1	PBLOCK	Parameter Block's Identifier field

Table A–1: Traceability between ACIS IP&CL fields and MSID keywords (Continued)

IP&CL Field Name[a]	Dim[b]	Len[c]	*m*[d]	Keyword[e]	Description
exposureTeFaintBias.windowBlockId	1	32	2	WIND_ID	Window List Parameter Block's Identifier field (0xffffffff if none used)
exposureTeFaintBias.biasStartTime	1	32	3	BIASTART	Science timestamp counter value at start of bias computation
exposureTeFaintBias.biasParameterId	1	32	4	BIAS_ID	Parameter Block Identifier from most recent bias computation
exposureTeFaintBias.ccdId	1	4	5	CCD_ID	Identify which CCD produced the data [§B.1]
exposureTeFaintBias.fepId	1	3	6	FEP_ID	Identify which FEP processed the data [§B.4]
exposureTeFaintBias.fepTimestamp	1	25	7	FEPSTAMP	FEP Timestamp when FEP received Beginning of Frame mark
exposureTeFaintBias.exposureNumber	1	32	8	EXPNO	Exposure Number since start of run (of the data just received)
exposureTeFaintBias.eventsSent	1	32	9	EVTSENT	Number of events telemetered in preceding set of data records
exposureTeFaintBias.thresholdPixels	1	32	10	THR_PIX	Number of pixels detected above their respective threshold levels
exposureTeFaintBias.discardEventAmplitude	1	32	11	DROP_AMP	Number of events discarded due to their corrected amplitude
exposureTeFaintBias.discardWindow	1	32	12	DROP_POS	Number of events discarded due to their CCD position
exposureTeFaintBias.discardGrade	1	32	13	DROP_GRD	Number of events discarded due to their Grade Code
exposureTeFaintBias.deltaOverclocks[4]	4	16[g]	14	DELTOCLK	Output node Delta Overclock values used for the completed exposure (delta = (exposure overclock) - (initial overclock)) (NOTE: In Full/Diag modes, the nodes are indexed as follows [A,B,C,D]. In AC mode, the nodes are [A,C,x,x]. In BD mode, the nodes are [B,D,x,x].
exposureTeFaintBias.biasParityErrors	1	32	15	BERR_SUM	Total number of pixel bias errors so far in the run
exposureTeFaintBias.initialOverclocks[4]	4	16	16	INITOCLK	Output node initial overclock values added to pixel map values (In Full/Diag Mode, nodes are ordered [A,B,C,D]. In AC mode, [A,C,x,x], and in BD mode, [B,D,x,x])
dumpedCcBlock.load1dBlock	**MSID=DUMP_CC_*m* (windows)**				**Load 1-D Window List Parameter Block**
load1dBlock.windowBlockId	1	32	50	WIND_ID	Identifies the 1D Window List Parameter Block
load1dBlock.windows[n].ccdId	n	4	51	CCD_ID	Selects to which CCD the window processes [§B.1]
load1dBlock.windows[n].ccdColumn	n	10	52	LL_CCDX	Selects the lowest CCD column index covered by the window
load1dBlock.windows[n].width	n	10	53	WIN_COLS	Selects the number of CCD Columns covered by the window (# of columns minus 1)
load1dBlock.windows[n].sampleCycle	n	8	54	WIN_ROWS	Selects how many events to skip between each accepted event
load1dBlock.windows[n].lowerEventAmplitude	n	12	55	PHAMIN	Selects the minimum event amplitude accepted by the window
load1dBlock.windows[n].eventAmplitudeRange	n	16	56	PHARANGE	Range of event amplitudes accepted by the window filter.
dumpedTeBlock.load2dBlock	**MSID=DUMP_TE_*m* (windows)**				**Load 2-D Window List Parameter Block**

Table A–1: Traceability between ACIS IP&CL fields and MSID keywords (Continued)

IP&CL Field Name[a]	Dim[b]	Len[c]	*m*[d]	Keyword[e]	Description
load2dBlock.windowBlockId	1	32	61	WIND_ID	Identifies the 2D Window List Parameter Block
load2dBlock.windows[n].ccdId	n	4	62	CCD_ID	Selects to which CCD the window processes [§B.1]
load2dBlock.windows[n].ccdRow	n	10	63	LL_CCDY	Selects the lowest CCD row index covered by the window
load2dBlock.windows[n].ccdColumn	n	10	64	LL_CCDX	Selects the lowest CCD column index covered by the window
load2dBlock.windows[n].width	n	10	65	WIN_COLS	Selects the number of CCD Columns covered by the window (# of columns minus 1)
load2dBlock.windows[n].height	n	10	66	WIN_ROWS	Selects the number of CCD Rows covered by the window (# of rows minus 1)
load2dBlock.windows[n].sampleCycle	n	8	67	SAMP_CYC	Selects how many events to skip between each accepted event
load2dBlock.windows[n].lowerEventAmplitude	n	12	68	PHAMIN	Selects the minimum event amplitude accepted by the window
load2dBlock.windows[n].eventAmplitudeRange	n	16	69	PHARANGE	Range of event amplitudes accepted by the window filter.
dumpedCcBlock.loadCcBlock	**MSID=DUMP_CC_*m***				**Load Continuous Clocking Parameter Block**
loadCcBlock.parameterBlockId	1	32	5	PBLOCK	Identifies the Continuous Clocking Parameter Block
loadCcBlock.fepCcdSelect[6]	6	4	6	CCD_ID	Array of Ccd Selections indexed by FEP Id. This identifies a CCD, where values 0 through 9 respectively select CCDs I0-I3 and S0-S5, and 10 acts as a deselect. [§B.1]
loadCcBlock.fepMode	1	4	7	FEP_MODE	Front End Selection Algorithm [§B.9.2]
loadCcBlock.bepPackingMode	1	4	8	BEP_MODE	Event List Packing Code [§B.10.2]
loadCcBlock.ignoreBadColumnMap	1	1	9	NOBADCOL	Disable use of Continuous Clocking Bad Column Map (0:Use, 1:Don't use)
loadCcBlock.recomputeBias	1	1	10	BIAS_CAL	Enable bias calibration when used for data run (0: Don't compute, 1:Compute)
loadCcBlock.trickleBias	1	1	11	SENDBIAS	Telemeter re-computed bias (0: Don't send, 1:Send)
loadCcBlock.rowSum	1	4	12	SUMROW	Number of CCD rows to sum in powers of 2
loadCcBlock.columnSum	1	4	13	SUMCOL	Number of CCD columns to sum in powers of 2
loadCcBlock.overclockPairsPerNode	1	4	14	OCLKPAIR	Number of pairs of (possibly summed) overclock pixels (per output node)
loadCcBlock.outputRegisterMode	1	2	15	ORC_MODE	Output Register Mode [§B.5]
loadCcBlock.ccdVideoResponse[6]	6	1	16	VIDRESP	Array of CCD video responses, indexed by FEP Id. In cases of conflict, the last entry wins. This selects the video chain response for a given CCD. 0 indicates 1:1, and 1 indicates a 1:4 response
loadCcBlock.fepEventThreshold[6][4]	6*4	16[g]	17–22	EVT_THR	Threshold set points for each output node coming into Fep 0

Table A–1: Traceability between ACIS IP&CL fields and MSID keywords (Continued)

IP&CL Field Name[a]	Dim[b]	Len[c]	*m*[d]	Keyword[e]	Description
loadCcBlock.fepSplitThreshold[6][4]	6*4	16	23–28	SPL_THR	Split Threshold set points for each output node coming into Fep 0
loadCcBlock.lowerEventAmplitude	1	16	29	PHAMIN	Minimum accepted event amplitude (pulse height filter)
loadCcBlock.eventAmplitudeRange	1	16	30	PHARANGE	Range of event amplitudes accepted by the pulse height filter.
loadCcBlock.gradeSelections[4]	4	1	31	GRADEMAP	Bitfield of accepted event grade code flags, indexed by grade code [§B.3]
loadCcBlock.rawCompressionSlotIndex	1	8	33	RCMPSLOT	Slot identifier of Compression table for raw mode from all FEPs (255 = no compression)
loadCcBlock.ignoreInitialFrames	1	16	34	EXP_SKIP	The number of whole exposure frames that the FEP is to ignore at the start of a bias calibration. If zero, accept all valid data after the first VSYNC.
loadCcBlock.biasAlgorithmId[6]	6	8	35	BIASALG	Selects bias algorithm to use for indexed FEP [§B.7.2]
loadCcBlock.biasRejection[6]	6	16	36	BIASREJ	Bias rejection parameter for indexed FEP [§B.7.2]
loadCcBlock.fepVideoOffset[6][4]	6*4	16	37–42	VID_OFF	Video Offset values for each output node coming into FEP 0
loadCcBlock.deaLoadOverride	1	32	43	DEALOAD	If not zero, pointer to explicit DEA Load in RAM
loadCcBlock.fepLoadOverride	1	32	44	FEPLOAD	If not zero, pointer to explicit FEP Load in RAM
dumpedTeBlock.loadTeBlock	**MSID=DUMP_TE_*m***				**Load Timed Exposure Parameter Block**
loadTeBlock.parameterBlockId	1	32	5	PBLOCK	Identifies the Timed Exposure Parameter Block
loadTeBlock.fepCcdSelect[6]	6	4	6	CCD_ID	Array of Ccd Selections indexed by FEP Id. This identifies a CCD, where values 0 through 9 respectively select CCDs I0-I3 and S0-S5, and 10 acts as a deselect. [§B.1]
loadTeBlock.fepMode	1	4	7	FEP_MODE	Front End Algorithm selection [§B.9.1]
loadTeBlock.bepPackingMode	1	4	8	BEP_MODE	Event List Packing Code [§B.10.1]
loadTeBlock.onChip2x2Summing	1	1	9	SUM_2X2	On-chip summing selection (0: none, 1: sum 2x2)
loadTeBlock.ignoreBadPixelMap	1	1	10	NOBADPIX	Disable use of Bad Pixel Map (0: Use, 1:Ignore Map)
loadTeBlock.ignoreBadColumnMap	1	1	11	NOBADCOL	Disable use of Timed Exposure Bad Column Map (0:Use, 1:Ignore Map)
loadTeBlock.recomputeBias	1	1	12	BIAS_CAL	Enable bias calibration when used for data run (0:Don't compute, 1:Compute)
loadTeBlock.trickleBias	1	1	13	SENDBIAS	Telemeter re-computed bias (0: Don't send, 1:Send)
loadTeBlock.subarrayStartRow	1	10	14	STARTROW	Index of first (possibly summed) row to clock out of the CCDs
loadTeBlock.subarrayRowCount	1	10	15	ROWCNT	One less than the number of (possibly summed) rows to clock out of the CCD

Table A–1: Traceability between ACIS IP&CL fields and MSID keywords (Continued)

IP&CL Field Name[a]	Dim[b]	Len[c]	*m*[d]	Keyword[e]	Description
loadTeBlock.overclockPairsPerNode	1	4	16	OCLKPAIR	Number of pairs of (possibly summed) overclock pixels (per output node)
loadTeBlock.outputRegisterMode	1	2	17	ORC_MODE	Output Register Clocking Mode [§B.5]
loadTeBlock.ccdVideoResponse[6]	6	1	18	VIDRESP	Array of CCD video responses, indexed by FEP Id. In cases of conflict, the last entry wins. This selects the video chain response for a given CCD. 0 indicates 1:1, and 1 indicates a 1:4 response.
loadTeBlock.primaryExposure	1	16	19	EXPTIMEA	Primary Exposure Time in 1/10 second units (NOTE: To achieve the minimum integration time, i.e. the smear time, use 0 and and only configure a single CCD. To achive 0.1 second integration time, one must configure only 1 or 2 CCDs, to achieve 0.2 second integration, configure fewer than 5 CCDs. If these constraints are exceeded, the system will improperly allow overlap of parallel transfers on two or more CCDs).
loadTeBlock.secondaryExposure	1	16	20	EXPTIMEB	Secondary Exposure Time in 1/10 second units (NOTE: To achieve the minimum integration time, i.e. the smear time, use 0 and only configure a single CCD. To achive 0.1 second integration time, configure only 1 or 2 CCDs, to achieve 0.2 second integration, configure fewer than 5 CCDs. If these constraints are exceeded, the system will improperly allow overlap of large parallel transfers on two or more CCDs).
loadTeBlock.dutyCycle	1	16	21	DTYCYCLE	Number of Secondary Exposures per Primary
loadTeBlock.fepEventThreshold[6][4]	6*4	16[g]	22–27	EVT_THR	Threshold set points for each output node coming into Fep 0
loadTeBlock.fepSplitThreshold[6][4]	6*4	16	28–33	SPL_THR	Split Threshold set points for each output node coming into Fep 0
loadTeBlock.lowerEventAmplitude	1	16	34	PHA_MIN	Minimum accepted event amplitude (pulse height filter)
loadTeBlock.eventAmplitudeRange	1	16	35	PHARANGE	Range of event amplitudes accepted by the pulse height filter. (0xffff: accepts all events that are not below Lower Event Amplitude)
loadTeBlock.gradeSelections[256]	256	1	36	GRADEMAP	This indicates if events whose grade corresponds to the field should be telemetered. 0 indicates don't send, 1 indicates send. [§B.3]
loadTeBlock.histogramCount	1	16	38	HISTOCNT	Number of exposures to accumulate histograms
loadTeBlock.biasCompressionSlotIndex[6]	6	8	39	BCMPSLOT	Slot identifier of Compression table for bias map from each FEP (255 = no compression)
loadTeBlock.rawCompressionSlotIndex	1	8	40	RCMPSLOT	Slot identifier of Compression table for raw mode data from all FEPs (255 = no compression)

Table A–1: Traceability between ACIS IP&CL fields and MSID keywords (Continued)

IP&CL Field Name[a]	Dim[b]	Len[c]	*m*[d]	Keyword[e]	Description
loadTeBlock.ignoreInitialFrames	1	16	41	EXP_SKIP	The number of whole exposure frames that the FEP is to ignore at the start of a bias calibration. If zero, accept all valid data after the first VSYNC.
loadTeBlock.biasAlgorithmId[6]	6	8	42	BIASALG	Selects bias algorithm to use for indexed FEP [§B.7.1]
loadTeBlock.biasArg0[6]	6	16[g]	43	BIASARG0	Bias exposure count for indexed FEP [§B.7.1]
loadTeBlock.biasArg1[6]	6	16[g]	44	BIASARG1	Bias parameter for indexed FEP [§B.7.1]
loadTeBlock.biasArg2[6]	6	16[g]	45	BIASARG2	Bias parameter for indexed FEP [§B.7.1]
loadTeBlock.biasArg3[6]	6	16[g]	46	BIASARG3	Bias parameter for indexed FEP [§B.7.1]
loadTeBlock.biasArg4[6]	6	16[g]	47	BIASARG4	Bias parameter for indexed FEP [§B.7.1]
loadTeBlock.fepVideoOffset[6][4]	6*4	16	48–53	VID_OFF	Video Offset values for each output node coming into FEP 0
loadTeBlock.deaLoadOverride	1	32	54	DEALOAD	If not zero, pointer to explicit DEA Load in RAM
loadTeBlock.fepLoadOverride	1	32	55	FEPLOAD	If not zero, pointer to explicit FEP Load in RAM
scienceReport	**MSID=SCI_REPORT_*m***				**Post-science run report sent at the end of a science or bias run**
scienceReport.runStartTime	1	32	0	RUNSTART	Science timestamp counter value at start of science run
scienceReport.parameterBlockId	1	32	1	PBLOCK	Parameter Block's Identifier field
scienceReport.windowBlockId	1	32	2	WIND_ID	Window List Parameter Block's Identifier field (0xffffffff if none used)
scienceReport.biasStartTime	1	32	3	BIASTART	Science timestamp counter value at start of bias computation
scienceReport.biasParameterId	1	32	4	BIAS_ID	Parameter Block Identifier from most recent bias computation
scienceReport.exposuresProduced	1	32	5	EXPTOT	Number of exposures produced by the CCDs during the run
scienceReport.exposuresSent	1	32	6	EXPSENT	Number of exposures telemetered by the run
scienceReport.biasErrorCount	1	32	7	BERR_TOT	Total number of pixel bias map errors detected during the run
scienceReport.fepErrorCodes[6]	6	8	8	FEP_ERRS	Array of codes, indexed by FEP_ID, indicating any errors were detected on the corresponding Fep during the run [§B.8]
scienceReport.ccdErrorFlags[6]	6	1	9	CCD_ERRS	Flag indicating if any errors were detected on DEA board used for CCD I/0 during the run
scienceReport.deaInterfaceErrorFlag	1	1	10	DEA_ERRS	Flag indicating if any errors were detected on the DEA Interface Board during the run
scienceReport.terminationCode	1	8	11	TERMCODE	Code indicating the reason for the end of the run [§B.11]

a. Taken from the ACIS IP&CL Structures definitions in Applicable Document 3.
b. This column defines the field dimension within an ACIS telemetry packet.

c. This column indicates the length in bits of the ACIS telemetry field. All fields represent unsigned integers, except where noted. More significant bytes preceed less significant bytes.
d. This column contains an integer that completes the MSID of the field.
e. The names in this column are used in Level 0 FITS headers.
f. When generated in compressed mode, this field will have varying length.
g. This field is a two's-complement signed integer. All other fields are unsigned.

Appendix B: ACIS Constants

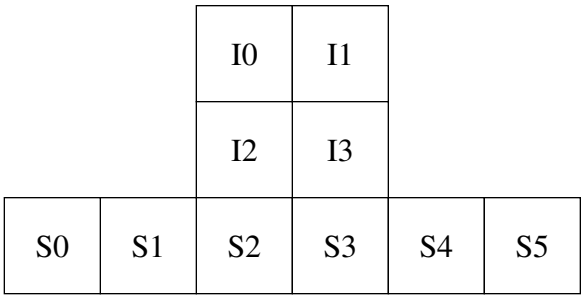
B.1 CCD Identifiers

The following values are used to identify a CCD. These codes are denoted `CCD_ID` in Table A–1:

Table B–1: `CCD_ID` Values

Value	Mnemonic	Description
0	CCD_I0	Imaging CCD I0
1	CCD_I1	Imaging CCD I1
2	CCD_I2	Imaging CCD I2
3	CCD_I3	Imaging CCD I3
4	CCD_S0	Spectroscopy CCD S0
5	CCD_S1	Spectroscopy CCD S1
6	CCD_S2	Spectroscopy CCD S2
7	CCD_S3	Spectroscopy CCD S3
8	CCD_S4	Spectroscopy CCD S4
9	CCD_S5	Spectroscopy CCD S5
10	CCD_DESELECT	Code used to indicate no CCD selection

For reference purposes only, the following diagram illustrates the relative layout of the indicated CCDs in the focal plane assembly, as viewed from the High Resolution Mirror Assembly (HRMA). This information was obtained from the Applicable Document 5.



B.2 CCD Row and Column Position Definition

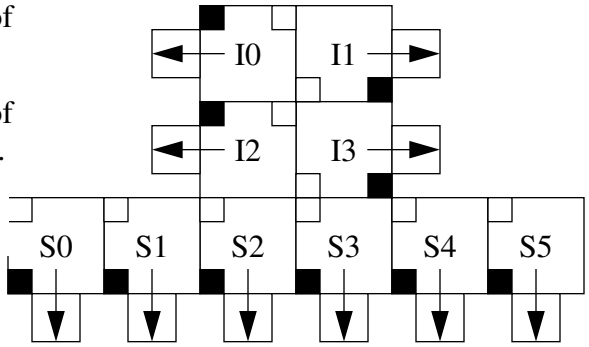
The following illustration defines the CCD Row and Column positions used by the ACIS Software. Row 0 is defined to be the CCD imaging row closest to the Framestore. Column 0 is defined

to be the left-most imaging column (*i.e.* for ABCD readout mode, the first to be clocked out of output node A).

■ Indicates relative location of CCD Row 0, Column 0.

□ Indicates relative location of CCD Row 1023, Column 0.

◄— Indicates clocking direction of the CCD.



B.3 Event Grade Code Definition

The following illustration defines the CCD Grade Code bit-definitions for a 3x3 event, where the row and column positions are indicated relative to the reported center of the event (the figure is also applicable to 5x5 events, which receive grades based on their inner 9 pixels).

3x3 Event

row				
	1	5	6	7
	0	3		4
	-1	0	1	2
		-1	0	1

column

Grade Code Bits

msb							lsb
7	6	5	4	3	2	1	0

The following illustration defines the CCD Grade Code bit-definitions for a 1x3 event, where the column positions are indicated relative to the reported center of the event.

1x3 Event

0		1
-1	0	1

column

Grade Code Bits

msb	lsb
1	0

B.4 FEP Identifiers

The following are used to identify specific Front End Processors. These codes are denoted FEP_ID in Table A–1:

Table B–2: FEP_ID Values

Value	Mnemonic	Description
0	FEP_0	FEP Slot 0 Identifier
1	FEP_1	FEP Slot 1 Identifier
2	FEP_2	FEP Slot 2 Identifier
3	FEP_3	FEP Slot 3 Identifier
4	FEP_4	FEP Slot 4 Identifier
5	FEP_5	FEP Slot 5 Identifier

B.5 Output Register Clocking Modes

The following codes are used to indicate how to clock a CCD's output register. These codes are denoted ORC_MODE in Table A–1:

Table B–3: ORC_MODE Values

Value	Mnemonic	Description
0	QUAD_FULL	Clock charge to all four output nodes
1	QUAD_DIAG	Clock charge away from all four output nodes
2	QUAD_AC	Clock charge toward output nodes A and C
3	QUAD_BD	Clock charge toward output nodes B and D

B.6 DEA Query Identifiers

The following lists the currently defined DEA Controller Housekeeping Query identifiers. They correspond to CCD_ID values of 10 and 11, i.e. the DEA interface control boards. The codes are denoted QUERY_ID in Table A–1:

Table B–4: DEA Controller QUERY_ID Values

Value	Mnemonic	Description
0	DEAHOUSE_CNTL_RELAY	Control relay flags
1	DEAHOUSE_CNTL_ADC_TMP_BEP_PCB	DPA Thermistor 1 - BEP PC Board
2	DEAHOUSE_CNTL_ADC_TMP_BEP_OSC	DPA Thermistor 2 - BEP Oscillator
3	DEAHOUSE_CNTL_ADC_TMP_FEP0_MONG	DPA Thermistor 3 - FEP 0 Mongoose
4	DEAHOUSE_CNTL_ADC_TMP_FEP0_PCB	DPA Thermistor 4 - FEP 0 PC Board
5	DEAHOUSE_CNTL_ADC_TMP_FEP0_ACTEL	DPA Thermistor 5 - FEP 0 ACTEL
6	DEAHOUSE_CNTL_ADC_TMP_FEP0_RAM	DPA Thermistor 6 - FEP 0 RAM
7	DEAHOUSE_CNTL_ADC_TMP_FEP0_FB	DPA Thermistor 7 - FEP 0 Frame Buf.
8	DEAHOUSE_CNTL_ADC_TMP_FEP1_MONG	DPA Thermistor 8 - FEP 1 Mongoose

Table B–4: DEA Controller QUERY_ID Values (Continued)

Value	Mnemonic	Description
9	DEAHOUSE_CNTL_ADC_TMP_FEP1_PCB	DPA Thermistor 9 - FEP 1 PC Board
10	DEAHOUSE_CNTL_ADC_TMP_FEP1_ACTEL	DPA Thermistor 10- FEP 1 ACTEL
11	DEAHOUSE_CNTL_ADC_TMP_FEP1_RAM	DPA Thermistor 11- FEP 1 RAM
12	DEAHOUSE_CNTL_ADC_TMP_FEP1_FB	DPA Thermistor 12- FEP 1 Frame Buf.
13	DEAHOUSE_CNTL_ADC_SUBAHK	DEA Video Board ADC
14	DEAHOUSE_CNTL_ADC_SPARE1	Spare - Unused
15	DEAHOUSE_CNTL_ADC_FPTEMP_12	Spare - Focal Plane Temp. Board 12
16	DEAHOUSE_CNTL_ADC_FPTEMP_11	Spare - Focal Plane Temp. Board 11
17	DEAHOUSE_CNTL_ADC_DPAGNDREF1	DPA Ground Reference 1
18	DEAHOUSE_CNTL_ADC_DPA5VHKA	DPA 5V Housekeeping A
19	DEAHOUSE_CNTL_ADC_DPAGNDREF2	DPA Ground Reference 2
20	DEAHOUSE_CNTL_ADC_DPA5VHKB	DPA 5V Housekeeping B
21	DEAHOUSE_CNTL_ADC_UNUSED1	Unused
22	DEAHOUSE_CNTL_ADC_UNUSED2	Unused
23	DEAHOUSE_CNTL_ADC_UNUSED3	Unused
24	DEAHOUSE_CNTL_ADC_UNUSED4	Unused
25	DEAHOUSE_CNTL_ADC_DEA28VDCA	PSMC A DEA 28V DC
26	DEAHOUSE_CNTL_ADC_DEA24VDCA	PSMC A DEA 24V DC
27	DEAHOUSE_CNTL_ADC_DEAM15VDCA	PSMC A DEA -15.5V
28	DEAHOUSE_CNTL_ADC_DEAP15VDCA	PSMC A DEA +15.5V
29	DEAHOUSE_CNTL_ADC_DEAM6VDCA	PSMC A DEA -6V DC
30	DEAHOUSE_CNTL_ADC_DEAP6VDCA	PSMC A DEA +6V DC
31	DEAHOUSE_CNTL_ADC_RAD_PCB_A	Relative Dose Rad. Monitor Side A
32	DEAHOUSE_CNTL_ADC_GND_1	Interface Ground Reference 1
33	DEAHOUSE_CNTL_ADC_DEA28VDCB	PSMC B DEA 28V DC
34	DEAHOUSE_CNTL_ADC_DEA24VDCB	PSMC B DEA 24V DC
35	DEAHOUSE_CNTL_ADC_DEAM15VDCB	PSMC B DEA -15.5V DC
36	DEAHOUSE_CNTL_ADC_DEAP15VDCB	PSMC B DEA +15.5V DC
37	DEAHOUSE_CNTL_ADC_DEAM6VDCB	PSMC B DEA -6V DC
38	DEAHOUSE_CNTL_ADC_DEAP6VDCB	PSMC B DEA +6V DC
39	DEAHOUSE_CNTL_ADC_RAD_PCB_B	Relative Dose Rad. Monitor Side B
40	DEAHOUSE_CNTL_ADC_GND_2	Interface Ground Reference 2

The following lists the currently defined DEA Analog Housekeeping Query identifiers. They correspond to CCD_ID values of 0–9, i.e. the DEA analog boards. These identifiers are based on Applicable Document 4. Queries which fail, either due to a time-out or because the queried board

is not powered, will be indicated in the telemetered housekeeping packet as having a value of `0xffff` in the queried data. The codes are denoted `QUERY_ID` in Table A–1:

Table B–5: DEA Analog `QUERY_ID` Values

Value	Mnemonic	Description
0	DEAHOUSE_CCD_REG_0	Register 0 Sequencer Control
1	DEAHOUSE_CCD_REG_1	Register 1 Video ADC Control
2	DEAHOUSE_CCD_REG_2	Register 2
3	DEAHOUSE_CCD_REG_3	Register 3
128	DEAHOUSE_CCD_PIA_P	Image Array Parallel +
129	DEAHOUSE_CCD_PIA_M	Image Array Parallel -
130	DEAHOUSE_CCD_PFS_P	Framestore Parallel +
131	DEAHOUSE_CCD_PFS_M	Framestore Parallel -
132	DEAHOUSE_CCD_S_P	Serial Register +
133	DEAHOUSE_CCD_S_M	Serial Register -
134	DEAHOUSE_CCD_R_P	Reset Gate +
135	DEAHOUSE_CCD_R_M	Reset Gate -
136	DEAHOUSE_CCD_OG	Output Gate Bias Level
137	DEAHOUSE_CCD_SCP	Scupper
138	DEAHOUSE_CCD_RD	Reset Diode
139	DEAHOUSE_CCD_DR0	Drain Output Channel A
140	DEAHOUSE_CCD_DR1	Drain Output Channel B
141	DEAHOUSE_CCD_DR2	Drain Output Channel C
142	DEAHOUSE_CCD_DR3	Drain Output Channel D
143	DEAHOUSE_CCD_SPARE	Spare Housekeeping Channel
144	DEAHOUSE_CCD_TEMP_BOARD	Board Temperature (RTD4)
145	DEAHOUSE_CCD_TEMP_SRAM	SRAM Temperature (RTD3)
146	DEAHOUSE_CCD_TEMP_ADC	ADC Temperature (RTD2)
147	DEAHOUSE_CCD_TEMP_ACTEL	Gate Array Temperature (RTD1)

B.7 Bias Algorithm Selection Codes

The following define the Bias Algorithm selection codes for Timed Exposure Mode and Continuous Clocking Mode. The determination of which algorithm is used and which parameters affect the computation is derived from the parameter values.

B.7.1 Timed Exposure Mode

Table B–6: `BIASALG` Values

Value	Mnemonic	Description
0	FEP_NO_BIAS	None
1	FEP_BIAS_1	Algorithm #1:Whole Frame Mode

Table B–6: `BIASALG` Values

Value	Mnemonic	Description
2	FEP_BIAS_2	Algorithm #2:Strip Mode

The following table (copied from the "FEP Timed Exposure Bias Calibration" section of Applicable Document 2) indicates how the parameters from the Timed Exposure Parameter Block (see "Load TE Block" in Applicable Document 3) affect the bias computation for each mode.

Table B–7: Timed Exposure Bias Parameter Usage

Field	"Whole-Frame" Mode	"Strip" Mode
BIASALG	FEP_BIAS_1	FEP_BIAS_2
BIASARG0	Number of conditioning exposures (PHASE2)	Number of exposures per pixel
BIASARG1	Number of approximation-to-mean exposures (PHASE3), including the conditioning exposures listed in BIASARG0.	=0 to use the *mean* algorithm =1 to use the *fractile* algorithm =2 to use the *medmean* algorithm
BIASARG2	Rejection threshold for low-pixel elimination (immediately prior to PHASE3)	For *mean* and *medmean*, specifies σ rejection criterion. For *fractile*, index of sorted pixel array.
BIASARG3	Threshold for event rejection (PHASE3)	Specifies how many of the largest samples are to be removed from the pixel array before applying the *mean*, *medmean*, or *fractile* algorithm.
BIASARG4	Rejection threshold for approximation-to-mean	Specifies how many of the smallest samples are to be removed from the pixel array before applying the *mean*, *medmean*, or *fractile* algorithm.

B.7.2 Continuous Clocking Mode

The following table (copied and adjusted from the "FEP Continuous Clocking Bias Calibration" section of Applicable Document 2) indicates how the parameters from the Continuous Clocking Parameter Block (see "Load Cc Block" in Applicable Document 3) affect the bias computation.

Table B–8: Continuous Clocking Bias Parameter Usage

Field	Description
BIASALG	=0 to use the iterated *mean* algorithm; =1 to use the *fractile* algorithm
BIASREJ	For *mean*, specifies σ rejection criterion. For *fractile*, index of sorted pixel array.

B.8 FEP Science Report Error Codes

The following list the FEP error codes supplied by the Science Run report. The first set of codes are defined by the FEP/BEP interface, and are supplied by the FEP in response to a command or action initiated by the BEP. The second set are defined by the BEP to report power, reset condi-

tions, or I/O error conditions when attempting to access a FEP. These codes are denoted FEP_ERRS in Table A–1:

Table B–9: FEP_ERRS Values

Value	Mnemonic	Description
0	FEP_CMD_NOERR	no errors detected
1	FEP_CMD_ERR_NO_RUN	no command currently running
2	FEP_CMD_ERR_UNK_CMD	unknown command type
3	FEP_CMD_ERR_PARM_LEN	parameter block too long
4	FEP_CMD_ERR_PARM_TYPE	unknown parameter block type
5	FEP_CMD_ERR_QUAD_CODE	unknown quadrant code
6	FEP_CMD_ERR_BIAS_TYPE	unknown bias type code
7	FEP_CMD_ERR_BIAS_PARM0	bad bias parm 0
8	FEP_CMD_ERR_NROWS	bad number of rows
9	FEP_CMD_ERR_NCOLS	bad number of columns
10	FEP_CMD_ERR_NOCLK	bad number of overclocks
11	FEP_CMD_ERR_NHIST	bad histogram exposure count
12	FEP_CMD_ERR_NO_PARM	no parameter block loaded
13	FEP_CMD_ERR_BAD_CMD	illegal secondary command
14	FEP_CMD_ERR_NO_BIAS	no bias map stored
128	FEP_ERR_LOCK_TIMEOUT	Timeout on FEP lock
129	FEP_ERR_NO_POWER	FEP has no power
130	FEP_ERR_IS_RESET	FEP is reset
131	FEP_ERR_NO_CMDRING	FEP program has no command mailbox
132	FEP_ERR_REPLY_TIMEOUT	FEP reply timed-out
133	FEP_ERR_BAD_REPLY_TYPE	FEP produced bad reply
134	FEP_ERR_BAD_MBOX_STATE	FEP mailbox state invalid

B.9 FEP Science Mode Codes

B.9.1 Timed Exposure Mode

The following define the FEP mode codes for Timed Exposure Mode. These codes are denoted FEP_MODE in Table A–1:

Table B–10: Timed-Exposure FEP_MODE Values

Value	Mnemonic	Description
0	FEP_TE_MODE_RAW	Raw Mode
1	FEP_TE_MODE_HIST	Histogram Mode
2	FEP_TE_MODE_EV3x3	3x3 Event Detection Mode
3	FEP_TE_MODE_EV5x5	5x5 Event Detection Mode

B.9.2 Continuous Clocking Mode

The following define the FEP mode codes for Continuous Clocking Mode. These codes are denoted `FEP_MODE` in Table A–1:

Table B–11: Continuous Clocking `FEP_MODE` Values

Value	Mnemonic	Description
0	`FEP_CC_MODE_RAW`	Raw Mode
1	`FEP_CC_MODE_EV1x3`	1x3 Event Detection Mode

B.10 BEP Packing Mode Codes

B.10.1 Timed Exposure

The following define the BEP Event List Packing Codes for Timed Exposure Mode. These codes are denoted BEP_MODE in Table A–1:

Table B–12: Timed Exposure BEP_MODE Values

Value	Mnemonic	Description
0	BEP_TE_MODE_FAINT	3x3 or 5x5 Faint Mode Event Telemetry
1	BEP_TE_MODE_FAINTBIAS	3x3 Faint with Bias Event Telemetry
2	BEP_TE_MODE_GRADED	3x3 Graded Event Telemetry
3	BEP_TE_MODE_EVHIST	3x3 Event Histogram Telemetry

B.10.2 Continuous Clocking

The following define the BEP Event List Packing Codes for Continuous Clocking Mode. These codes are denoted BEP_MODE in Table A–1:

Table B–13: Continuous Clocking BEP_MODE Values

Value	Mnemonic	Description
0	BEP_CC_MODE_FAINT	1x3 Faint Mode Event Telemetry
1	BEP_CC_MODE_GRADED	1x3 Graded Event Telemetry

B.11 Science Mode Termination Codes

The following list the science mode termination reason codes. These codes are denoted TERM-CODE in Table A–1:

Table B–14: TERMCODE Values

Value	Mnemonic	Description
0	SMTERM_UNUSED	Unused
1	SMTERM_STOPCMD	Commanded to Stop i.e. normal term.
2	SMTERM_BIASDONE	Bias-only Run completed
3	SMTERM_RADMON	Radiation Monitor was asserted
4	SMTERM_CLOBBERED	Clobbered by another start command
5	SMTERM_FEP_BIAS_START	FEP Bias Processing did not start
6	SMTERM_FEP_DATA_START	FEP Data Processing did not start
7	SMTERM_CCD_BIAS_START	Cmd. start clock. CCDs for bias failed
8	SMTERM_CCD_DATA_START	Cmd. start clock. CCDs for data failed
9	SMTERM_CCD_BIAS_STOP	Cmd. stop clock. CCDs for bias failed
10	SMTERM_PROC_PARM_INVALID	Processing Parameter out of range
11	SMTERM_DEA_PARM_INVALID	DEA Parameter out of range
12	SMTERM_FEP_PARM_INVALID	FEP Parameter out of range

Table B–14: TERMCODE Values (Continued)

Value	Mnemonic	Description
13	SMTERM_FEP_CONFIG_ERROR	FEP Configuration Error
14	SMTERM_DEA_IO_ERROR	I/O errors, or no CCD controllers on
15	SMTERM_FEP_IO_ERROR	I/O errors, or no FEPs are on
16	SMTERM_UNSPECIFIED	Reason is unspecified

B.12 Miscellaneous FEP Constants

The following list some miscellaneous constants and limits used by the Front End Processor software. The mnemonics are those used by the ACIS flight software.

Table B–15: Miscellaneous FEP Constants

Mnemonic	Value	Description
BIAS_BAD	0xffe	bias parity error value
PIXEL_BAD	0xfff	pixel in bad pixel map
MAX_NOCLK	30	maximum overclocks per output node
MAX_NOCLKR	16	max raw overclocks per output node
MAX_NROWS	1024	maximum number of pixel rows
MAX_NCOLS	1024	maximum number of pixel columns
MAX_STRIPS	64	maximum bparm[0] in strip mode
CCLK_NROWS	512	number of pixel rows in CClk mode
PIXEL_MASK	0xfff	valid pixel and bias bits
INITSKIP	2	number of science exposures to skip

B.13 Miscellaneous BEP Constants

The following list some miscellaneous constants and limits used by the Back End Processor software. The mnemonics are those used by the ACIS flight software.

Table B–16: Miscellaneous BEP Constants

Mnemonic	Value	Description
CORNER_MEAN_LOW	-4096	Graded Mode Corner Mean below -4095
CORNER_MEAN_MISSING	4095	Graded Mode—No Valid Corner Pixels