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-1.0	ASC FITS File Designer's Guide `http://hea-www.harvard.edu/~jcm/asc/fits/ascfits.ps`
10	...	HEASARC proposal for time/date formats in FITS headers `ftp://nssdc.gsfc.nasa.gov/pub/fits/year2000_proposal.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, which do not contain

BINTABLE extensions). Each entry in these files, apart from generic ASC header keywords, 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 1 (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 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. Both files are sorted into time order, as implied by §5.3 and §5.4 of Applicable Document 6. Pixel addresses are expressed in CCD coordinates in which the row and column indices 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 1-1024 based `CHIPX,CHIPY` coordinate system used in Level 1 processing.

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(TBD).

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.

1.6 Other Modes and Formats

The following categories of ACIS telemetry are used for maintenance and diagnostic purposes, and only preliminary descriptions are included within the interface defined by this document:

- Data derived from Timed-Exposure and Continuous-clocking Raw Pixel modes
- Data derived from Timed-Exposure Histogram mode
- Memory Dumps (except the System Configuration Table)
- Back-End Processor Software Housekeeping

The following categories are not yet covered by this document:

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

2.0 Environment

2.1 Hardware Characteristics and Limitations

All binary integers within ACIS Level 0 products are written in "big-endian" format, i.e. with their more significant bytes preceding their less significant bytes (this is the byte order used by Sun, SGI, and Apple machines, in contrast with the "little-endian" format used by Dec and Intel processors). 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 *n*B.

These products contain double-precision binary 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 and 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.

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

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.

3.2 Input / Output Protocol

All Level 0 products can be accessed by FITSIO library routines (see Applicable Document 8) that support the `BINTABLE` extension. 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.

3.3 Timing and Sequencing Characteristics

The natural subdivision ("atomic unit") of ACIS telemetry is the Science Run, which signals its start by writing a *dumpedTeBlock* or *dumpedCcBlock* packet to the science telemetry stream, and which continues until the next such packet. By contrast, the natural subdivision of AXAF data is the Observation Request (OR), which may span several ACIS science runs. ACIS telemetry will therefore be processed in batches, each spanning the period of a single observation request, and the data products will be further sub-divided into individual science runs.

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 1 (for ACIS Timed-Exposure mode) and Table 2 (for Continuous Clocking mode). The names obey the following convention:

`acis0Vnn_nns000000000_f_product.fits`

where `'acis0'` denotes an ACIS Level 0 file, `'Vnn_nn'` is the version of the AXAF IP&CL used to decode the telemetry packets (e.g. V05_02 for IP&CL version 5.02) , `'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 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. 4.2), and the (optional) `'f_'` denotes the index of a particular ACIS front end processor (FEP). Note that the System Configuration files violate this convention in that their `'f'` field counts the number of times that this table appears in the telemetry. For Histogram files only, the field`'f_'` is also appended, to indicate the CCD node for which the histogram was compiled

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

Title	File Name	Contents
TE Parameter File	`*_tepbk.fits`	Timed exposure (TE) science run parameters
2-D Window File	`*_win2.fits`	Optional TE (2-dimensional) window filter parameters
Science Report File	`*_srr.fits`	Science run report (common to TE and CC modes)
DEA Housekeeping	`*_deahk.fits`	DEA housekeeping report
System Configuration	`*_sys.fits`	The *m*'th readout of the system configuration table
Exposure File	`*_f_exr.fits`	Per-exposure statistics, one per FEP
Bias Error File	`*_f_berr.fits`	Optional bias pixel parity errors, one per FEP
Pixel Event File (various formats depending on instrument mode)	`*_f_evtef.fits`	TE faint (3x3) event file
	`*_f_evtefb.fits`	TE faint-with-bias (3x3) event file
	`*_f_evteg.fits`	TE graded event file
	`*_f_evtevf.fits`	TE very faint (5x5) event file
Bias File	`*_f_tebias.fits`	TE CCD bias array file, one per FEP
Image File	`*_f_teraw.fits`	TE CCD image (raw mode only), one per FEP
Histogram File	`*_f_n_hist.fits`	Histogram of CCD pixel values, for node n (TE histogram mode only)
Software Housekeeping	`*_swhk.fits`	Software housekeeping report
Memory Dump File	`*_mem.fits`	Memory dumps (bad pixels, patches, Huffman tables, etc)

Table 2: ACIS Level 0 Continuous Clocking Data Product Files

Title	File Name	Contents
CC Parameter File	`*_ccpbk.fits`	Continuous clocking (CC) science run parameters
1-D Window File	`*_win1.fits`	Optional CC (1-dimensional) window filter parameters
Science Report File	`*_srr.fits`	Science run report (common to TE and CC modes)
DEA Housekeeping	`*_deahk.fits`	DEA housekeeping report
System Configuration	`*_sys.fits`	The *m*'th readout of the system configuration table
Exposure File	`*_f_exr.fits`	Per-exposure statistics, one per FEP
Bias Error File	`*_f_berr.fits`	Optional bias pixel parity errors, one per FEP
Pixel Event File	`*_f_evccf.fits`	CC faint (1x3) event file
	`*_f_evccg.fits`	CC graded event file
Bias File	`*_f_ccbias.fits`	CC CCD bias array file, one per FEP
Image File	`*_f_ccraw.fits`	CC CCD row 'image' (raw mode only), one per FEP
Software Housekeeping	`*_swhk.fits`	Software housekeeping report
Memory Dump File	`*_mem.fits`	Memory dumps (bad pixels, patches, Huffman tables, etc)

4.2 The Origin and Content of Time Fields

All CCD exposures (frames) obtained by ACIS are tagged with the value of the (nominally) 100 kHz BEP counter, whose value is reported once per telemetry science frame (2.05 second). The BEP clock values may thereby be related to the more accurate spacecraft clock via the VCDU counters in the telemetry minor frame headers. During Level 0 processing, the VCDU counters are themselves related to observatory UTC, *i.e.* earth receipt UTC minus one-way light time, via a method TBD.

In the header of each data file is recorded the S/C UTC corresponding to the BEP counter values for the first and last CCD exposures processed[1] during the science run, in keywords `TSTART` and `TSTOP`, respectively (the values of `DATE-OBS` and `TIME-OBS` correspond to `TSTART`). The corresponding BEP clock values are recorded as `STARTBEP` and `STOPBEP`, respectively. The start of the science run itself (i.e. runStartTime in the ACIS IP&CL; Applicable Document 3) is 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` (corresponding to `TSTART`) and `STOPMJF`, `STOPMNF` (corresponding to `TSTOP`). 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 are found in major 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 (TBD).

Two time values are recorded for each frame in the exposure record files (see Section 4.4.4). These values are `BEPTICKS`, the BEP clock value at the start of the exposure, and `TIME`, the

1. Typically, 2 exposures are skipped (not processed) at the start of a Science Run; `TSTART` corresponds to the time of the first exposure *processed*.

mid-exposure S/C UTC. `TIME` is calculated according to the following, for timed exposure (TE) and continuous clocking (CC) modes:

TE: = `TSTART+SCETDIFF+0.05*EXPTIME`
CC: = `TSTART+SCETDIFF+(TROW+.5)*EXPTIME*10`$^{-6}$

where `SCETDIFF` is the number of seconds (TAI) elapsed since `TSTART` and is derived from the BEP counter value for the exposure in question (note that the units of `EXPTIME` are 0.1 s for TE mode and microseconds for CC mode). The value of `TIME` corresponding to a given exposure is also placed in each event record (see Section 4.4.6 and Section 4.4.7).

Some less time-critical ACIS telemetry packets contain an alternative time field, `BEPCOUNT`. This represents the number of BEP timer interrupts since the last processor reset. Although the nominal interrupt time is 100 milliseconds, this may vary with processor load. In practice, the accompanying `SCETDIFF` values are reliable to 2.05 seconds.

The format of times & dates contained in the primary FITS headers of Level 0 data products (Table 3) shall conform to the proposal described in Applicable Document 10.

4.3 Structure and Organization Overview

The “science run” forms a natural unit by which ACIS telemetry can, and should, be divided. The Level 0 processing system shall therefore segregate its products by run number. 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.

4.4 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. 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 files, which are described in Section 4.4.11 below, all ACIS Level 0 files contain Binary Table extensions.

Table 3 shows the keywords that will be present in the headers of all ACIS Level 0 products, whether they describe binary tables or images. Each 80 byte line is left justified and 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).

The binary tables are further described by an extension header that immediately follows the keyword header of Table 3. The format of a “generic” FITS binary table file is shown in Table 4—the header, composed of lines of 80-byte ASCII characters, begins with a group of “required” keywords (`XTENSION` through `GCOUNT`), continues with zero or more product-specific keywords, and ends with `TFIELDS` and groups of keywords (`TFORM`*m* through `TLMAX`*m*) that define each column of the binary table that follows the FITS header. After the terminating `‘END’` keyword, blank bytes are added until the length of the extension header is a multiple of 2880 bytes. In the

Table 3: Format of a 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 Event File: ACIS Level 0
COMMENT
MISSION = 'AXAF    '           / Advanced X-ray Astrophysics Facility
TELESCOP= 'AXAF    '           / Telescope used
INSTRUME= 'ACIS    '           / AXAF CCD Imaging Spectrometer
OBS_ID  = 'RX-EE-1.001A'       / Observation ID from OFLS
DATE-OBS= '25/02/97'           / Date of observation start
TIME-OBS= '20:00:00'           / Time of observation start
DATE-END= '25/02/97'           / Date of observation end
TIME-END= '20:34:06'           / Time of observation end
MJD-OBS =          58904.84293 / MJD of observation start
BIAS_DAT= '26/02/96'           / Obs date of Bias frame
BIAS_TIM= '15:14:09'           / Obs time of Bias frame
CREATOR = 'psci 2.3'           / Program creating this file
ASCVER  = 'ACIS_L0_2.0'        / Format spec for this file
ORIGIN  = 'ASC     '           / Organization creating file
DATE    = '26/02/96  '         / Date file was created
REVISION=                    0 / Processing revision
EVENT   = 'EVENTS  '           / PROS: Name of extension with events
DATACLAS= 'OBSERVED'           / Data is observed, not simulated
MJDREFI =                50814 / MJD of clock start
MJDREFF =          0.000731296 / 63.184/86400
TSTART  =          825365629.0 / Observation start time, seconds
TSTOP   =          825366847.0 / Observation stop time, seconds
TELAPSE =               1218.0 / Elapsed time, seconds
TIMEUNIT= 's       '           / HEASARC: time unit
TIMESYS = '1998.0  '           / HEASARC: time system
TIMEDEL =          0.200000003 / Smallest meaningful time increment, s
TIMEREF = 'LOCAL   '           / Time is local for data
TIMVERSN= 'OGIP/93-003a'       / OGIP time convention
TASSIGN = 'SATELLITE  '        / Source of time assignment
COMMENT
COMMENT   AXAF FITS Event File: Special ACIS Keywords
COMMENT
READMODE= 'TIMED   '           / CCD exposure mode
DATAMODE= 'FAINT   '           / CCD event telemetry mode
RUN_ID  =                    1 / Science run index
STARTBEP=                    0 / BEP timer value at TSTART
STOPBEP=                     0 / BEP timer value at TSTOP
STARTMJF=                    0 / Maj frame containing start of Sci Run
STARTMNF=                    0 / Min frame containing start of Sci Run
STOPMJF =                    0 / Maj frame containing end of Sci Run
STOPMNF =                    0 / Min frame containing end of Sci Run
COMMENT
COMMENT  Product-specific keywords are inserted here
END
```

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.

Table 4: Format of a FITS 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 = ‘EVENTS  ‘     / Table name
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)
TFORM2  =             nC / Dimension and data type of second field.
TTYPE2  = ‘name2   ’     / Label of second field
TUNIT2  = ‘units2  ’     / Data units of second field (optional)
TLMIN2  =        minval2 / Minimum field value (optional)
TLMAX2  =        maxval2 / 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

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 3), and blank bytes are added until it, too, is a multiple of 2880 bytes in length.

Note that Table 3 and Table 4 will require UPDATING based on Applicable Document 9 (which is in draft form as of this writing).

4.4.2 Parameter Block Files

Table 5: Timed Exposure Parameter Block File (`*_tepbk.fits`)

Additional FITS Keyword Header Items

```
PBLOCK  ='0x80000001'     / Parameter Block Identifier
WIND_ID ='0xa0000001'     / Window block Identifier
FEP_MODE=               2 / 0:Raw; 1:Histogram; 2:3x3; 3:15 TBD
BEP_MODE=               1 / 0:Faint; 1:Faint Bias; 2:Graded; 3:15 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 / Primary exposure time in units of 1/10s
EXPTIMEB=               0 / Secondary exposure time in 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)

FITS binary table contents (one entry per active FEP) (Continued)					
Field	**TTYPE**	**TUNIT**	**TFORM**	**TLMAX**[a]	**Comment**
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.

The instrument configuration for each science run will be described by a Parameter Block File, either for Timed Exposure Mode (Table 5) or Continuous Clocking Mode (Table 6). 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.

Table 6: Continuous Clocking Parameter Block File (`*_ccpbk.fits`)

Additional FITS Keyword Header Items

```
PBLOCK  ='0x80000001'    / Parameter Block Identifier
WIND_ID ='0xa0000001'    / Window block Identifier
FEP_MODE=              2 / 0:Raw; 1:Histogram; 2:1x3; 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)
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	2B	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

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 7). In Continuous Clocking Mode, they are one-dimensional (Table 8).

Table 7: 2-Dimensional Window Block File (`*_win2.fits`)

Additional FITS Keyword Header Items					
`WIND_ID ='0xe0000001'     / 2-Dimensional 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	2B	65535	Range of event amplitudes accepted by window

Table 8: 1-Dimensional Window Block File (`*_win1.fits`)

Additional FITS Keyword Header Items					
`WIND_ID ='0xe0000001'     / 2-Dimensional 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

An Exposure Records file (Table 9) is created for each FEP that generates exposure packets. This file contains a binary table with one row for each exposure. Since the FEP will skip exposures when it is incapable of processing the incoming events fast enough, the exposure counters (`EXPNO`) will be in ascending order, but some exposures may be missing.

Table 9: Exposure Records File (`*_f_exr.fits`)

Additional FITS Keyword Header Items

```
RUNSTART=         3924313546 / Science Run Start in units of BEP clock
PBLOCK  ='0x80000001'        / Parameter Block Identifier
WIND_ID ='0xa0000001'        / Window block Identifier
BIASTART=         3895671628 / Bias Run Start in units of BEP ticks
BIAS_ID ='0x80000002'        / PBLOCK for last bias calibration
FEP_ID  =                  2 / Front End Processor ID: 0-5
CCD_ID  =                  1 / CCD id: 0 - 9
```

FITS binary table contents (one entry per CCD exposure)

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

a. TLMIN is zero, except where noted.
b. 0.1 seconds for timed exposure mode; microseconds for continuous clocking.

4.4.5 Bias Error Files

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 10), one for each FEP that reported at least one such error during that particular science run.

Table 10: Bias Error File (`*_f_berr.fits`)

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**	**Comment**
1	TIME	s	1D	n/a	S/C UTC 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

4.4.6 Timed-Exposure Event Files

In one of the timed-exposure modes, all X-ray events from a given FEP are written to one of the event files described in Table 11 through Table 14. The `EXPNO` field serves as an index into the accompanying exposure record file.

Table 11: TE Faint Event Data File (`*_f_evtef.fits`)

Additional FITS Keyword Header Items					
`FEP_ID = 2 / Front End Processor ID: 0-5` `CCD_ID = 1 / CCD id: 0 - 9`					
FITS binary table contents (one entry per event)					
#	**TTYPE**	**TUNIT**	**TFORM**	**TLMAX**	**Comment**
1	TIME	s	1D	n/a	S/C UTC 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

Table 12: TE Faint-with-bias Event Data File (`*_f_evtefb.fits`)

Additional FITS Keyword Header Items

```
FEP_ID  =                    2 / Front End Processor ID: 0-5
CCD_ID  =                    1 / CCD id: 0 - 9
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)
```

FITS binary table contents (one entry per event)

#	TTYPE	TUNIT	TFORM	TLMAX	Comment
1	TIME	s	1D	n/a	S/C UTC 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

Table 13: TE Graded Event Data File (`*_f_evteg.fits`)

Additional FITS Keyword Header Items

```
FEP_ID  =                    2 / Front End Processor ID: 0-5
CCD_ID  =                    1 / CCD id: 0 - 9
```

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 UTC 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	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 14: TE Very Faint Event Data File (`*_f_evtevf.fits`)

Additional FITS Keyword Header Items					
FEP_ID = 2 / Front End Processor ID: 0-5 CCD_ID = 1 / CCD id: 0 - 9					
FITS binary table contents (one entry per event)					
#	**TTYPE**	**TUNIT**	**TFORM**	**TLMAX**	**Comment**
1	TIME	s	1D	n/a	S/C UTC 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

4.4.7 Continuous Clocking Event Files

In one of the continuous-clocking modes, all X-ray events from a given FEP are written to one of the event files described in Tables 15–16. The EXPNO field serves as an index into the accompanying exposure record file.

Table 15: CC Faint Event Data File (`*_f_evccf.fits`)

Additional FITS Keyword Header Items					
FEP_ID = 2 / Front End Processor ID: 0-5 CCD_ID = 1 / CCD id: 0 - 9					
FITS binary table contents (one entry per CCD exposure frame)					
Field	**TTYPE**	**TUNIT**	**TFORM**	**TLMAX**	**Comment**
1	TIME	s	1D	n/a	S/C UTC 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

Table 16: CC Graded Event Data File (`*_f_evccg.fits`)

Additional FITS Keyword Header Items					
FEP_ID = 2 / Front End Processor ID: 0-5 CCD_ID = 1 / CCD id: 0 - 9					
FITS binary table contents (one entry per CCD exposure frame)					
Field	**TTYPE**	**TUNIT**	**TFORM**	**TLMAX**	**Comment**
1	TIME	s	1D	n/a	S/C UTC corresponding to row readout

Field	TTYPE	TUNIT	TFORM	TLMAX	Comment
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	8190	Bias-corrected pulse-height of the 1x3 event
6	FLTGRADE	n/a	1I	15	Grade code of the event

4.4.8 Science Run Report File

Finally, each science run is summarized in a Report File (Table 17).

Table 17: Science Run Report File (`*_srr.fits`)

Additional FITS Keyword Header Items

```
RUNSTART=         3924313546 / Science Run Start in units of BEP clock
PBLOCK  ='0x80000001'        / Parameter Block Identifier
WIND_ID ='0xa0000001'        / Window block Identifier
BIASTART=         3895671628 / Bias Run Start in units of BEP ticks
BIAS_ID ='0x80000002'        / PBLOCK for last bias calibration
EXPTOT  =                335 / total number of exposures produced
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
SOFT_VER=                 11 / Instrument software version number
```

FITS binary table contents (one entry per active FEP)

Field	TTYPE	TUNIT	TFORM	TLMAX	Comment
1	FEP_ID	n/a	1I	5	FEP reporting error
2	CCD_ERRS	n/a	1I	1	code indicating errors on DEA during science run
3	FEP_ERRS	n/a	1I	255	code indicating errors on FEP during science run

4.4.9 Analog Housekeeping Files

All housekeeping telemetry received from the DEA analog boards and from the DEA interface controllers during a science run shall be decommutated by the Level 0 processing system and written to a DEA Housekeeping File (Table 18). The interpretation of DEA_VAL depends on the values of CCD_ID and QUERY_ID, as described in Appendix B.6.

Table 18: DEA Housekeeping File (`*_deahk.fits`)

Additional FITS Keyword Header Items

```
RUNSTART=      3924313546 / Science Run Start in units of BEP clock
DEA_ID  =      3221225473 / DEA parameter block identifier (0xc0000001)
```

FITS binary table contents (one entry per reported DEA channel)

Field	TTYPE	TUNIT	TFORM	TLMAX	Comment
1	DEA_CHAN	n/a	1I	256	DEA channel reporting value
2	SCETDIFF	s	1D	n/a	Time in seconds since start of observation (TSTART)
3	BEPCOUNT	0.1 s	1J	2^{31}-1	BEP timer tick interrupt counter value
4	CCD_ID	n/a	1I	10	CCD Identifier (0-9) to choose the corresponding DEA CCD Controller, or CCD_DESELECT (10) to choose the DEA interface board
5	QUERY_ID	n/a	1I	255	DEA query code sent to board (see Appendix B.6).
6	DEA_VAL	n/a	2B	65535	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.

4.4.10 System Configuration Table Files

Should the system configuration table be downlinked to the telemetry stream during the science run[1], it will be written to a System Configuration file (Table 18). The numerous analog housekeeping channels are described in Applicable Document 4. Note that all columns of the binary table contain 16-bit unsigned fields.

Table 19: System Configuration File (*_sys.fits)

Additional FITS Keyword Header Items
`SCETDIFF=         1234.5 / Seconds (TAI) since TSTART`
`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`

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

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	2B	0	65535	Sequencer Offset
3	VADC_OFF	n/a	2B	0	65535	Video ADC Offset
4	VCDSABM	n/a	2B	0	65535	Video Channel Disable Mask
5	HHKPADDR	n/a	2B	0	65535	Hold Housekeeping Address
6	BJD_ENAB	n/a	2B	0	65535	Back-Junction Diode Enable
7	HST_DSAB	n/a	2B	0	65535	High-speed tap disable
8	DAC_PIAP	n/a	2B	0	65535	Image Array Parallel +
9	DACPIAMP	n/a	2B	0	65535	Image Array Parallel -+
10	DAC_PIAM	n/a	2B	0	65535	Image Array Parallel -
11	DAC_PFSP	n/a	2B	0	65535	Framestore Parallel +
12	DACPFSMP	n/a	2B	0	65535	Framestore Parallel -+
13	DAC_PFSM	n/a	2B	0	65535	Framestore Parallel -
14	DAC_S_P	n/a	2B	0	65535	Serial Register +
15	DAC_S_M	n/a	2B	0	65535	Serial Register -
16	DAC_R_P	n/a	2B	0	65535	Reset Gate +
17	DAC_R_MP	n/a	2B	0	65535	Reset Gate -+
18	DAC_R_M	n/a	2B	0	65535	Reset Gate -
19	DAC_SCP	n/a	2B	0	65535	Scupper
20	DAC_OG_P	n/a	2B	0	65535	Output Gate +
21	DAC_OG_M	n/a	2B	0	65535	Output Gate -
22	DAC_RD	n/a	2B	0	65535	Reset Diode
23	DAC_DR0	n/a	2B	0	65535	Drain Output (A)
24	DAC_DR1	n/a	2B	0	65535	Drain Output (B)
25	DAC_DR2	n/a	2B	0	65535	Drain Output (C)
26	DAC_DR3	n/a	2B	0	65535	Drain Output (D)
27	DAC_AOFF	n/a	2B	0	65535	A channel offset
28	DAC_BOFF	n/a	2B	0	65535	B channel offset
29	DAC_COFF	n/a	2B	0	65535	C channel offset
30	DAC_DOFF	n/a	2B	0	65535	D channel offset

4.4.11 Bias Map Files

Unique among the Level 0 products, 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 20) will always contain 1024x1024 pixels, and continuous-clocking bias maps (Table 21) 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, column and/or row summation in CC mode).

“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).

Table 20: TE Bias Map File (`*_f_tebias.fits`)

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 (=512 for CC maps)
COMMENT
COMMENT   AXAF FITS TE Bias File: ACIS Level 0
COMMENT
MISSION = ‘AXAF    ‘           / Advanced X-ray Astrophysics Facility
TELESCOP= ‘AXAF    ‘           / Telescope used
INSTRUME= ‘ACIS    ‘           / AXAF CCD Imaging Spectrometer
DATE-OBS= ‘25/02/97’           / Date of observation start
TIME-OBS= ‘20:00:00’           / Time of observation start
MJD-OBS =          58904.84293 / MJD of observation start
CREATOR = ‘psci 2.3’           / Program creating this file
ASCVER  = ‘ACIS_L0_2.0’        / Format spec for this file
ORIGIN  = ‘ASC     ‘           / Organization creating file
DATE    = ‘26/02/96’           / Date file was created
REVISION=                    0 / Processing revision
EVENT   = ‘EVENTS  ‘           / PROS: Name of extension with events
DATACLAS= ‘OBSERVED’           / Data is observed, not simulated
MJDREFI =                50814 / MJD of clock start
MJDREFF =          0.000731296 / 63.184/86400
TSTART  =          825365629.0 / Observation start time, seconds
TELAPSE =               1218.0 / Elapsed time, seconds
TIMEUNIT= ‘s       ‘           / HEASARC: time unit
TIMESYS = ‘1998.0  ‘           / HEASARC: time system
```

Table 20: TE Bias Map File (`*_f_tebias.fits`) (Continued)

FITS Keyword Header

```
TIMEDEL =          0.200000003 / Smallest meaningful time increment, s
TIMEREF = ‘LOCAL   ‘           / Time is local for data
TIMVERSN= ‘OGIP/93-003a’       / OGIP time convention
TASSIGN = ‘SATELLITE  ‘        / Source of time assignment
COMMENT
COMMENT   AXAF FITS TE Bias File: Special ACIS Keywords
COMMENT
READMODE= ‘TIMED   ‘           / CCD exposure mode
DATAMODE= ‘FAINT   ‘           / CCD telemetry mode
RUN_ID  =                    1 / Science run index
STARTBEP=                    0 / BEP timer value at TSTART
STOPBEP=                     0 / BEP timer value at TSTOP
STARTMJF=                    0 / Maj frame containing start of Sci Run
STARTMNF=                    0 / Min frame containing start of Sci Run
STOPMJF =                    0 / Maj frame containing end of Sci Run
STOPMNF =                    0 / Min frame containing end of Sci Run
FEP_ID  =                    0 / FEP id: 0 - 5
CCD_ID  =                    7 / CCD id: 0 - 9
CCDROW1 =                    1 / Index of first CCD row
CCDNROWS=                 1024 / Number of CCD rows
CCDNODES=                    4 / Number of CCD output nodes
ORC_MODE=                    0 / CCD readout mode
SUM2X2  =                    0 / Pixel summation: YES or 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 integers

Table 21: CC Bias Map File (`*_f_ccbias.fits`)

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
COMMENT
COMMENT   AXAF FITS CC Bias File: ACIS Level 0
COMMENT
MISSION = ‘AXAF    ‘           / Advanced X-ray Astrophysics Facility
TELESCOP= ‘AXAF    ‘           / Telescope used
INSTRUME= ‘ACIS    ‘           / AXAF CCD Imaging Spectrometer
DATE-OBS= ‘25/02/97’           / Date of observation start
TIME-OBS= ‘20:00:00’           / Time of observation start
MJD-OBS =          58904.84293 / MJD of observation start
CREATOR = ‘psci 2.3’           / Program creating this file
ASCVER  = ‘ACIS_L0_2.0’        / Format spec for this file
ORIGIN  = ‘ASC     ‘           / Organization creating file
DATE    = ‘26/02/96’           / Date file was created
REVISION=                    0 / Processing revision
EVENT   = ‘EVENTS  ‘           / PROS: Name of extension with events
DATACLAS= ‘OBSERVED’           / Data is observed, not simulated
MJDREFI =                50814 / MJD of clock start
MJDREFF =          0.000731296 / 63.184/86400
TSTART  =          825365629.0 / Observation start time, seconds
TELAPSE =               1218.0 / Elapsed time, seconds
TIMEUNIT= ‘s       ‘           / HEASARC: time unit
TIMESYS = ‘1998.0  ‘           / HEASARC: time system
```

Table 21: CC Bias Map File (`*_f_ccbias.fits`) (Continued)

FITS Keyword Header

<pre>TIMEDEL =   0.200000003 / Smallest meaningful time increment, s
TIMEREF = 'LOCAL   '   / Time is local for data
TIMVERSN= 'OGIP/93-003a'   / OGIP time convention
TASSIGN = 'SATELLITE '   / Source of time assignment
COMMENT
COMMENT   AXAF FITS CC Bias File: Special ACIS Keywords
COMMENT
READMODE= 'CONTINUOUS'   / CCD exposure mode
DATAMODE= 'FAINT   '   / CCD telemetry mode
RUN_ID =   1 / Science run index
STARTBEP=   0 / BEP timer value at TSTART
STOPBEP=   0 / BEP timer value at TSTOP
STARTMJF=   0 / Maj frame containing start of Sci Run
STARTMNF=   0 / Min frame containing start of Sci Run
STOPMJF =   0 / Maj frame containing end of Sci Run
STOPMNF =   0 / Min frame containing end of Sci Run
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</pre>

followed by padding sufficient to make the header a multiple of 36 lines (2880 bytes)
FITS image array
1024 X 512 image pixels—16-bit integers

4.4.12 Raw Mode (Image) Files

In either TE or CC modes, raw pixel data can be telemetered via the “raw” telemetry packing format. Table 20 and Table 21 describe the L0 data products corresponding to these formats. In CC mode (Table 21), one image is written per 512-row block or ‘frame’

Table 22: TE Image File (`*_f_teraw.fits`)

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
COMMENT
COMMENT   AXAF FITS TE Image File: ACIS Level 0
COMMENT
MISSION = ‘AXAF    ‘           / Advanced X-ray Astrophysics Facility
TELESCOP= ‘AXAF    ‘           / Telescope used
INSTRUME= ‘ACIS    ‘           / AXAF CCD Imaging Spectrometer
DATE-OBS= ‘25/02/97’           / Date of observation start
TIME-OBS= ‘20:00:00’           / Time of observation start
MJD-OBS =          58904.84293 / MJD of observation start
CREATOR = ‘psci 2.3’           / Program creating this file
ASCVER  = ‘ACIS_L0_2.0’        / Format spec for this file
ORIGIN  = ‘ASC     ‘           / Organization creating file
DATE    = ‘26/02/96’           / Date file was created
REVISION=                    0 / Processing revision
EVENT   = ‘EVENTS  ‘           / PROS: Name of extension with events
DATACLAS= ‘OBSERVED’           / Data is observed, not simulated
MJDREFI =                50814 / MJD of clock start
MJDREFF =          0.000731296 / 63.184/86400
TSTART  =          825365629.0 / Observation start time, seconds
TELAPSE =               1218.0 / Elapsed time, seconds
TIMEUNIT= ‘s       ‘           / HEASARC: time unit
TIMESYS = ‘1998.0  ‘           / HEASARC: time system
```

Table 22: TE Image File (`*_f_teraw.fits`) (Continued)

FITS Keyword Header

```
TIMEDEL =          0.200000003 / Smallest meaningful time increment, s
TIMEREF = 'LOCAL   '           / Time is local for data
TIMVERSN= 'OGIP/93-003a'       / OGIP time convention
TASSIGN = 'SATELLITE  '        / Source of time assignment
COMMENT
COMMENT   AXAF FITS TE Bias File: Special ACIS Keywords
COMMENT
READMODE= 'TIMED   '           / CCD exposure mode
DATAMODE= 'RAW     '           / CCD telemetry mode
RUN_ID  =                    1 / Science run index
STARTBEP=                    0 / BEP timer value at TSTART
STOPBEP=                     0 / BEP timer value at TSTOP
STARTMJF=                    0 / Maj frame containing start of Sci Run
STARTMNF=                    0 / Min frame containing start of Sci Run
STOPMJF =                    0 / Maj frame containing end of Sci Run
STOPMNF =                    0 / Min frame containing end of Sci Run
FEP_ID  =                    0 / FEP id: 0 - 5
CCD_ID  =                    7 / CCD id: 0 - 9
CCDROW1 =                    1 / Index of first CCD row
CCDNROWS=                 1024 / Number of CCD rows
CCDNODES=                    4 / Number of CCD output nodes
ORC_MODE=                    0 / CCD readout mode
SUM2X2  =                    0 / Pixel summation: YES or NO
DEAGAIN =                    0 / Video gain setting: 0:high, 1:low
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 integers

Table 23: CC Image File (`*_f_ccraw.fits`)

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`
`COMMENT`
`COMMENT   AXAF FITS CC Image File: ACIS Level 0`
`COMMENT`
`MISSION = ‘AXAF    ‘            / Advanced X-ray Astrophysics Facility`
`TELESCOP= ‘AXAF    ‘            / Telescope used`
`INSTRUME= ‘ACIS    ‘            / AXAF CCD Imaging Spectrometer`
`DATE-OBS= ‘25/02/97’            / Date of observation start`
`TIME-OBS= ‘20:00:00’            / Time of observation start`
`MJD-OBS =          58904.84293 / MJD of observation start`
`CREATOR = ‘psci 2.3’            / Program creating this file`
`ASCVER  = ‘ACIS_L0_2.0’         / Format spec for this file`
`ORIGIN  = ‘ASC     ‘            / Organization creating file`
`DATE    = ‘26/02/96’            / Date file was created`
`REVISION=                    0 / Processing revision`
`EVENT   = ‘EVENTS  ‘            / PROS: Name of extension with events`
`DATACLAS= ‘OBSERVED’            / Data is observed, not simulated`
`MJDREFI =                50814 / MJD of clock start`
`MJDREFF =          0.000731296 / 63.184/86400`
`TSTART  =          825365629.0 / Observation start time, seconds`
`TELAPSE =               1218.0 / Elapsed time, seconds`
`TIMEUNIT= ‘s       ‘            / HEASARC: time unit`
`TIMESYS = ‘1998.0  ‘            / HEASARC: time system`

Table 23: CC Image File (`*_f_ccraw.fits`) (Continued)

FITS Keyword Header

<pre>TIMEDEL =   0.200000003 / Smallest meaningful time increment, s
TIMEREF = ‘LOCAL   ‘   / Time is local for data
TIMVERSN= ‘OGIP/93-003a’   / OGIP time convention
TASSIGN = ‘SATELLITE ‘   / Source of time assignment
COMMENT
COMMENT   AXAF FITS CC Bias File: Special ACIS Keywords
COMMENT
READMODE= ‘CONTINUOUS‘   / CCD exposure mode
DATAMODE= ‘RAW   ‘   / CCD telemetry mode
RUN_ID =   1 / Science run index
STARTBEP=   0 / BEP timer value at TSTART
STOPBEP=   0 / BEP timer value at TSTOP
STARTMJF=   0 / Maj frame containing start of Sci Run
STARTMNF=   0 / Min frame containing start of Sci Run
STOPMJF =   0 / Maj frame containing end of Sci Run
STOPMNF =   0 / Min frame containing end of Sci Run
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
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</pre>

followed by padding sufficient to make the header a multiple of 36 lines (2880 bytes)
FITS image array
1024 X 512 image pixels—16-bit integers

4.4.13 Histogram Files

In TE histogram mode, the number of pixels vs. pixel value (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 10..

Table 24: Histogram File (`*_f_n_hist.fits`)

Additional FITS Keyword Header Items

```
RUNSTART=        3924313546 / Science Run Start in units of BEP clock
PBLOCK  ='0x80000001'       / 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
HISTOCNT=                 1 / Number of exposures per histogram
STARTEXP=                 2 / Starting exposure used for histogram
ENDEXP=                  31 / Ending exposure used for histogram
EXPCOUNT=                30 / # of exposures used to produce histogram
FEPSTAMP='0x80000001'       / 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 bias error)

#	TTYPE	TUNIT	TFORM	TLMAX	Comment
1	CHANNEL	ADU	1I	4095	ADU channel
2	COUNTS	COUNTS	1J	1024^2	Number of pixels reportingADU value of given channel

4.4.14 Software Housekeeping Files

.

Table 25: Software Housekeeping File (`*_swhk.fits`)

Additional FITS Keyword Header Items

```
RUNSTART=        3924313546 / Science Run Start in units of BEP clock
PBLOCK  ='0x80000001'       / Parameter Block Identifier
STARTBEP=                   / BEP counter value at start of statistics
ENDBEP=                     / BEP counter value at end of statistics
```

FITS binary table contents (one entry per bias error)

#	TTYPE	TUNIT	TFORM	TLMAX	Comment
1	STATID	n/a	1I?	255?	ID of statistic being reported
2	COUNT	n/a	1J?	???	Count of number of occurences of event or condition
3	VALUE	n/a	1J?	???	Last reported HK value associated w/ event or condition

4.5 Volume, Size, and Frequency Estimates

TBD.