AXAF Science Center

Imaging Mode Pipeline Data Products: Level 2 to ASC Archive Interface Control Document

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`http://hea-www.harvard.edu/~adam/asc/icd/level2icd_12.ps`

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Document and Change Control Log

Document and Change Control Log			
Date	**Version**	**Section**	**Status**
08/04/1998	1.0	all	Initial draft
08/25/1998	1.1	Event list	Added list of header keywords with the rules on how to calculate their values
11/12/1998	1.2	all	"Mode" added to the title Added placeholders for GIF images in summary info CHIPX, CHIPY replaced DETX,DETY in HRC Event List ACIS event list modified to conform to ACIS Level 1 ICD v. 1.7 `changebar` package introduced Lists of DataModel and WCS keywords added to header descriptors

Unresolved issues

The following are the most important unresolved issues, as of 11/12/1998 :

1. Propagation of header keywords not addressed.
2. Volume, size, and frequency estimates are not included.
3. Header merging rules for Level 2 event list need to be reviewed.

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Chapter 1

Introduction

This document describes the interface to be employed in transferring the products of Standard Data Processing from the ASC Level 2 processing pipeline to the ASC Data Archive, according to the requirements stipulated in Applicable Document 1.

1.1 Purpose

This document describes the structure and content of the files created during Level 2 pipeline processing of AXAF data from all detectors in imaging mode. Level 2 processing is described in Applicable Document 2.

1.2 Scope

This interface shall apply to all Science Instrument-related data products that are generated by ASC Level 2 pipelines and distributed to the ASC Data Archive (see Applicable Documents 1 and 2) during the course of the AXAF mission.

1.3 Applicable documents

1. ASC AMO-2400 (SE03)
   ASC Data System Requirements (ASC.302.93.0008)

2. ASC AMO-2401 (DS01)
   ASC Data System Software Design (ASC.500.93.0006)

3. NOST 100-1.1
   Definition of the Flexible Image Transport System (FITS)
   `http://www.cv.nrao.edu/fits/`

4. OGIP 93-001
   HEASARC FITS Standards
   `http://legacy.gsfc.nasa.gov/docs/heasarc/ofwg/ofwg_intro.html`
   `ftp://legacy.gsfc.nasa.gov/fits_info/ofwg_recomm/recomm.txt`

5. ASC-FITS-1.1
   ASC FITS File Designers' Guide
   `http://hea-www.harvard.edu/~arots/asc/fits/ascfits.ps`

6. Header Merging Rules
   `http://hea-www.harvard.edu/~jcm/asc/docs/headers/header.rules`

7. FITS File Names for the AXAF Archive
   `http://hea-www.harvard.edu/~arots/asc/archive/files.html`

8. HTML 4.0 Specification
   `http://www.w3.org/TR/REC-html40/`

9. Graphics Interchange Format Programming Reference, CompuServe Incorporated, 31 July 1990

10. PostScript Language Reference Manual, 2nd edition, Adobe Systems Inc., Addison-Wesley, December 1990

11. HRC Data Products: Level 1 to ASC Archive Interface Control Document
    `http://hea-www.harvard.edu/asclocal/sds/development/ICD/`

12. ACIS Data Products: Level 1 to ASC Archive Interface Control Document
    `http://hea-www.harvard.edu/asclocal/sds/development/ICD/`

13. DETECT tools: Data Products Interface Document
    `http://hea-www.harvard.edu/asclocal/sds/projects/detect/detecticd.ps`

14. Exposure Map data product
    `http://space.mit.edu/ASC/analysis/Exposure_Maps/Exp_DP.ps.gz`

1.4 Functional description

1.4.1 Data format summary

Data sets generated by the Level 2 processing pipeline shall consist of data files in the following formats: plain (unformatted) ASCII, HTML, GIF, PostScript, and FITS.

ASCII files conform to ISO standard, with `^J` as the newline marker. Individual lines may be of different length.

HTML files conform to HTML-4.0 specifications (Applicable Document 8).

The Graphical Interchange Format (GIF) files conform to the definition given in Applicable Document 9.

The PostScript (Applicable Document 10) files are in "printable" (not Encapsulated) PostScript, i.e. they can be sent without any preprocessing to a PostScript-friendly printer. PostScript files may contain one or more pages.

ASC FITS files, in addition to conforming to the FITS format (Applicable Document 3), further conform to HEASARC standards (Applicable Document 4). FITS files consist of multiple HDUs (Header Data Units) and contain one principal HDU and multiple auxiliary HDUs. They are either images, with an IMAGE HDU as the first and possibly only HDU, or tables, in which case the first HDU in the file is a null HDU, with the principal BINTABLE HDU in a later section of the file.

1.4.2 Timing and sequencing characteristics

TBR.

1.4.3 Recipients and utilization

The primary recipients of Level 2 data products, via distribution from the archive, are AXAF observers, who will utilize these data products for scientific data analysis. The ASC may also make use of specific Level 2 data products for instrument calibration, instrument and/or spacecraft monitoring and trends analysis, and validation and verification of the Level 0, 1, and 2 software and of the data products themselves.

1.4.4 Pertinent relationships with other interfaces

Changes to HRC or ACIS Level 1 data products, as described in Applicable Documents 11–12, may affect the Level 2 data products described in the current document.

1.5 Assumptions and constraints

Level 2 processing shall generate a set of product files as shown in Table 2.1. Level 2 products shall be created on a UNIX file system. While the FITS files are being written, their headers may contain invalid keyword values (e.g. NAXIS2, the number of binary table rows). Care must be taken not to read or copy these files until they are complete.

1.6 Products not covered

TBR Level 2 products that are used for maintenance and diagnostic purposes (i.e. that are not supplied to the User for science data analysis), and/or are generic AXAF Level 2 products, are not currently included within the interface defined by this document.

Chapter 2

Detailed interface specifications

2.1 Labeling and identification

The data files generated by the Level 2 processing pipeline shall be assigned external names as shown in Table 2.1. The names obey the following convention (Applicable Document 7):

```
<i><s><t><v>_<c>[<l>][<.ext>]
```

where: <i> specifies the instrument, <s> specifies data source, with possible values: x=XRCF, f=Flight, t=TRW, b=Ball Bros., c=other lab calibration, s=simulated, and u=unknown, <t> is a 9-digit time stamp (integer part of TSTART, padded with leading zeros), <v> is the processing run ID "N###", <c> specifies the contents of the file (see Table 2.1). Optional <l> denotes the processing level, i.e. will be set to '2' for Level 2 data. Optional <.ext> denotes the format of the data product: .html, .gif, .ps, and .fits for HTML, GIF, PostScript, and FITS files, respectively.

2.2 Substructure definition and format

2.2.1 ASCII

The only Level 2 data product in plain ASCII format is the stack file containing the list of Level 1 files used in the creation of Level 2 event list.

2.2.2 HTML, GIF, PostScript

HTML, GIF, and PostScript files are used for observation summary information. The contents of the files are TBD.

2.2.3 FITS

The reader is referred to Applicable Document 5 for a detailed discussion of the components of the primary header and all extensions of the FITS files.

Primary Header keywords This header contains four keywords that are required in all FITS files. In addition, it contains short versions of configuration control, timing info, and observation info keywords, as defined in Applicable Document 5.

The header ends with a terminating END keyword.

File name	**Contents**	**Comments**
`*_stk2`	ASCII list of Level 1 files (stack file)	
`*_evt2.fits`	FITS filtered event list	
`*_cell.fits`	FITS source candidate list	Not covered in this document see Applicable Document 13
`*_src.fits`	FITS list of accepted sources	
`*_summ.html`	HTML summary info	
`*_TBD.gif`	GIF image(s) for summary info	
`*_summ.ps`	PostScript summary info	
`*_TBD.fits`	FITS predicted background map	Future
`*_TBD.fits`	FITS exposure map	Not covered in this document see Applicable Document 14
`*_TBD.fits`	FITS aspect histogram	Not covered in this document
`*_TBD.fits`	FITS PI spectra of target and N (TBD) brightest sources	Future
`*_TBD.fits`	FITS light curves of target and N (TBD) brightest sources	Future

Table 2.1: Level 2 Data Product Files

Principal HDU Header keywords The principal HDU is further described by an extension header. The header, composed of lines of 80-byte ASCII characters, contains a group of keywords required in FITS extensions, configuration control keywords, observation information keywords, timing-related keywords, and keywords defining each column of the binary table that follows the header, as defined in Applicable Document 5.

Additional keywords are required for columns that have coordinate systems attached.

The header ends with a terminating END keyword.

Auxiliary HDU Header keywords In addition to FITS required keywords, auxiliary HDU headers contain short versions of the configuration control, observation information, and timing keywords.

Column definition keywords, and—if needed—coordinate system-related keywords are present in the auxiliary HDU header.

The header ends with a terminating END keyword.

Chapter 3

Data products

3.1 List of Level 1 files (stack file)

This is an unformatted ASCII file, containing in each line the root file name of Level 1 data products that were used to create the Level 2 event list.

Each line in the stack file will contain the following info:

```
<i><s><t><v>[_<c>]
```

where: <i> specifies the instrument (acis, hrci, or hrcs), <s> specifies data source, with possible values: x=XRCF, f=Flight, t=TRW, b=Ball Bros., c=other lab calibration, s=simulated, and u=unknown, <t> is a 9-digit time stamp (integer part of TSTART, padded with leading zeros), <v> is the processing run ID, "N###".

For ACIS event files obtained in interleaved frame time mode only, optional <c> is a filename discriminator specifying the exposure cycle.

3.2 Event List

The FITS Event List contains a null primary header, a principal HDU binary table containing the information on X-ray events, and one or more auxiliary HDU binary tables containing information on Good Time Intervals.

Level 2 event list is created by concatenating all Level 1 event lists relevant to the analyzed observation. Only events that fall within the standard Good Time Intervals and pass the good event criteria are included.

3.2.1 Principal HDU: Event Data

The keywords describing the Level 2 event list are listed in Table 3.1. Since the Level 2 event list is in principle a concatenation of several Level 1 event lists, the values stored in several keywords need to be recalculated; Table 3.1 lists the rules that need to be followed in doing so, following the scheme presented in Applicable Document 6.

World Coordinate System (WCS) keywords are attached to the X, Y columns to give an RA and Dec coordinate system.

```
HDUNAME = 'EVENTS  '            / HDU name
CONTENT = 'EVT2    '
HDUCLASS= 'OGIP    '
HDUCLAS1= 'EVENTS  '
HDUCLAS2= 'ACCEPTED'
ORIGIN                  WarnFirst, Force ASC
CREATOR                 WarnFirst, Force <toolname>
CHECKSUM                CalcForce
DATASUM                 CalcForce
DATE                    CalcForce
DATE-OBS                CalcForce
DATE-END                CalcForce
TIMEUNIT                Fail;Default s
TIMEPIXR                Fail;Default 0.5
TIMEDEL                 Max
MISSION                 Fail(*)
TELESCOP                Fail(*)
INSTRUME                Fail(*)
DETNAM                  Fail(*)
GRATING                 Fail(*)
OBJECT                  Merge Merged; Force Unknown
TITLE                   Merge Merged; Force Unknown
OBSERVER                Merge Merged; Force Unknown
OBS_ID                  Merge Merged; Force Unknown
SIM_X                   WarnOmit 0.001
SIM_Y                   WarnOmit 0.001
SIM_Z                   WarnOmit 0.001
OBS_MODE                Fail(*)
RA_NOM                  WarnOmit 0.0003
DEC_NOM                 WarnOmit 0.0003
ROLL_NOM                WarnOmit 1.0
EQUINOX                 WarnPrefer 2000.0
RADECSYS                WarnPrefer ICRS
DATACLAS                WarnPrefer Observed
ONTIME                  CalcForce(*)
LIVETIME                CalcForce(*)
DTCOR                   CalcForce(*)
```

Table 3.1: Level 2 event list generic keywords, together with rules on how to determine their values. Keywords marked with "(*)" have rules different from recommendations presented in Applicable Document 6.

HRC

In addition to required keywords, as outlined in Applicable Document 5, the header of the HRC Level 2 event list contains HRC-specific keywords, listed in Table 3.2.

SHYPLUS	WarnOmit
SHYMINUS	WarnOmit
BPIXFILE	WarnOmit
ADCCORF	WarnOmit
GAINCORF	WarnOmit
DEGAP	WarnOmit

Table 3.2: HRC-specific keywords in the header of the principal HDU of the Event List, together with rules on how to determine their values.

The WCS and DataModel keywords in the HRC Level 2 Event List are listed in Table 3.3.

```
TCTYP4  = 'RA---TAN'            / Sky WCS
TCTYP5  = 'DEC--TAN'            / Sky WCS
TCRVL4  =                   0.0 / Sky coord of 1st axis (deg.)
TCRVL5  =                   0.0 / Sky coord of 2nd axis (deg.)
TCDLT4  =            -3.415E-5 / X degrees per pixel
TCDLT5  =             3.415E-5 / Y degrees per pixel
TCROT5  =                   0.0 / Rotation angle (degrees)
TCRPX4  =               16384.5 / Pixel corresponding to TCRVL4
TCRPX5  =               16384.5 / Pixel corresponding to TCRVL5
TCUNI4  = 'deg     '            / Unit of sky coords
TCUNI5  = 'deg     '            / Unit of sky coords
MTYPE1  = 'CHIP    '            / CHIP is ASC-HRC-1.1
MFORM1  = 'CHIPX,CHIPY'         / Components of CHIP
MTYPE2  = 'SKY     '            / SKY is ASC-FP-2.1
MFORM2  = 'X,Y     '            / Components of SKY
ACSYS1  = 'CHIP:AXAF-HRC-1.1'
ACSYS2  = 'SKY:AXAF-FP-1.2'
```

Table 3.3: WCS and DataModel keywords in the principal HDU of the HRC Event List.

Column entries are listed in Table 3.4.

#	TTYPE	TUNIT	TFORM	TLMIN	TLMAX	Comment
1	TIME	s	1D			Time tag (TT)
2	CHIPX	pixel	1I	1	16384/4096	Chip X
3	CHIPY	pixel	1I	1	16384	Chip Y
4	X	pixel	1D	0.5	32768.5/65534.5	Sky X
5	Y	pixel	1D	0.5	32768.5/65534.5	Sky Y
6	PHA	chan	1I	0	255	Pulse height
7	PI	chan	1I	0	255	Pulse invariant
8	STATUS		32X			Event status bits

Table 3.4: HRC Event Data principal HDU contents (one entry per event). Multiple TLMAX entries indicate HRC-I/HRC-S values.

ACIS

In addition to required keywords, as outlined in Applicable Document 5, the header of the ACIS Level 2 event list contains several specific keywords, listed in Table 3.5.

SCI_RUNS=	1 / Number of science runs processed
READMODE	Fail
DATAMODE	Fail
GAINFILE	WarnOmit
GRD_FILE	Fail
GRD_SCHM	Fail
ONTIMEn	CalcForce
LIVTIMEn	CalcForce

Table 3.5: ACIS-specific keywords in the header of the principal HDU of the Event List, together with rules on how to determine their values.

The WCS and DataModel keywords in the ACIS Level 2 Event List are listed in Table 3.6. Column entries are listed in Table 3.7.

```
TCTYP9  = 'RA---TAN'           / Sky WCS
TCTYP10 = 'DEC--TAN'           / Sky WCS
TCRVL9  =                  0.0 / Sky coord of 1st axis (deg.)
TCRVL10 =                  0.0 / Sky coord of 2nd axis (deg.)
TCDLT9  =            -1.375E-4 / X degrees per pixel
TCDLT10 =             1.375E-4 / Y degrees per pixel
TCROT10 =                  0.0 / Rotation angle (degrees)
TCRPX9  =               4096.5 / Pixel corresponding to TCRVL9
TCRPX10 =               4096.5 / Pixel corresponding to TCRVL10
TCUNI9  = 'deg     '           / Unit of sky coords
TCUNI10 = 'deg     '           / Unit of sky coords
MTYPE1  = 'CHIP    '           / CHIP is ASC-HRC-1.1
MFORM1  = 'CHIPX,CHIPY'        / Components of CHIP
MTYPE2  = 'TDET    '           / TDET is ASC-HRC-1.1
MFORM2  = 'TDETX,TDETY'        / Components of TDET
MTYPE3  = 'DET     '           / DET is ASC-FP-2.1
MFORM3  = 'DETX,DETY'          / Components of DET
MTYPE4  = 'SKY     '           / SKY is ASC-FP-2.1
MFORM4  = 'X,Y     '           / Components of SKY
ACSYS1  = 'CHIP:AXAF-ACIS-1.1'
ACSYS2  = 'TDET:AXAF-TDET-1.0'
ACSYS3  = 'DET:AXAF-FP-1.2'
ACSYS4  = 'SKY:AXAF-FP-1.2'
```

Table 3.6: WCS and DataModel keywords in the principal HDU of the ACIS Event List.

#	TTYPE	TUNIT	TFORM	TLMIN	TLMAX	Comment
1	TIME	s	1D			Time tag (TT)
2	CCD_ID		1I	0	9	CCD reporting event
3	CHIPX	pixel	1I	2	1023	X pos. of center pixel, chip coords.
4	CHIPY	pixel	1I	2/1	1023/512	Y pos. of center pixel, chip coords.
5	TDETX	pixel	1I	2	8191	X pos. of event, ACIS tiled coords.
6	TDETY	pixel	1I	1	8192	Y pos. of event, ACIS tiled coords.
7	DETX	pixel	1I			X pos. of event, ACIS detector coords.
8	DETY	pixel	1I			Y pos. of event, ACIS detector coords.
9	X	pixel	1E			X pos. of event, ACIS sky coords.
10	Y	pixel	1E			Y pos. of event, ACIS sky coords.
11	PHA	adu	1J	0	36855/12284	Total pulse height of event (ADU)
12	ENERGY	eV	1E	0	10^6	Nominal energy of event (eV)
13	PI	chan	1I			Pulse invariant energy of event
14	FLTGRADE		1I	0	255/3	Event grade, flight system
15	GRADE		1I			"Binned" event grade
16	STATUS		16X			Event status bits

Table 3.7: ACIS Event Data principal HDU contents (one entry per event). "Slashed" entries for TLMIN and TLMAX indicate values for TE and CC modes.

3.2.2 Auxiliary HDUs: Good Time Intervals

Level 2 HRC event file contains one GTI extension. This HDU has header keyword EXTNAME set to 'GTI'.

Level 2 ACIS event file contains up to 10 GTI extensions, one for each CCD. These HDUs have header keyword EXTNAME set to 'GTIn', where n is the CCD ID.

The bintable entries are shown in Table 3.8.

#	TTYPE	TUNIT	TFORM	Comment
1	START	s	1D	GTI start
2	STOP	s	1D	GTI stop

Table 3.8: Good Time Interval auxiliary HDU contents

3.3 Source candidate list

This file contains the "rough" positions and counts of source candidates detected with the sliding cell tool `celldetect`. This data product is described in a separate Interface Control Document (Applicable Document 13).

3.4 List of accepted sources

The objects from the Source Candidate List are subjected to a "reality check" via fitting to the local PSF. Candidates that yield acceptable fit and candidates with spatial extent larger than the PSF are considered "true" sources and labeled as point and extended sources, respectively (candidates with extent smaller than PSF are considered spurious).

The FITS list of accepted sources contains a null primary header and one binary table extension, which contains information on point and extended sources.

In addition to required keywords, as outlined in Applicable Document 5, and keywords propagated from the Level 2 event list and the exposure map, the header contains several data product specific keywords, listed in Table 3.9.

```
HDUNAME = 'SRCLIST '           / HDU name
HDUCLASS= 'OGIP    '
HDUCLAS1= 'SRCLIST '
SNR_THR =                 2.75 / SNR threshold for source candidates
GDNS_THR=                 0.90 / Goodness-of-fit acceptance threshold
```

Table 3.9: Keywords specific to the list of accepted sources in the principal HDU.

Column entries are listed in Table 3.10.

#	TTYPE	TUNIT	TFORM	TLMIN	TLMAX	Comment
1	RA	deg	1E	0.0	360.0	Source Right Ascension
2	RA_ERR	deg	1E			Source Right Ascension error
3	DEC	deg	1E	-90.0	90.0	Source Declination
4	DEC_ERR	deg	1E			Source Declination error
5	X	pixel	1E			Source X position
6	X_ERR	pixel	1E			Source X position error
7	Y	pixel	1E			Source Y position
8	Y_ERR	pixel	1E			Source Y position error
9	NPIXSOU	pixel	1I			Number of pixels in source region
10	NET_COUNTS	count	1E			Net source counts
11	NET_COUNTS_ERR	count	1E			Error in net source counts
12	BKG_COUNTS	count	1E			Background counts (scaled to source cell)
13	BKG_COUNTS_ERR	count	1E			Error in bkg counts (scaled to source cell)
14	NET_RATE	count/s	1E			Source count rate
15	NET_RATE_ERR	count/s	1E			Source count rate error
16	BKG_RATE	count/s/pixel	1E			Background count rate
17	BKG_RATE_ERR	count/s/pixel	1E			Background count rate error
18	EXPTIME	s	1E			Effective exposure time
19	SNR		1E			Source signal-to-noise
20	GOODNESS		1E			Goodness of PSF fit
21	THETA	arcmin	1E			Off axis angle
22	EE50_OBS	arcsec	1E			Observed 50 percent EE radius
23	EE50_PSF	arcsec	1E			PSF 50 percent EE radius
24	EXTENDED_SRC		1L			True if extended source
25	INCL_ANGLE	deg	1E	-90.0	90.0	Inclination angle
26	MAJ_AXIS	arcsec	1E			Major axis
27	MIN_AXIS	arcsec	1E			Minor axis
28	MULT_SRC		1L			True if more than 1 src fit simultaneously

Table 3.10: Contents of the list of accepted sources. One line per source.

3.5 Summary info

3.5.1 HTML file

TBD

3.5.2 GIF file(s)

TBD

3.5.3 PostScript file

TBD

3.6 Predicted background map

As of 11/12/1998 , Level 2 pipeline does not provide the predicted background map. It is, however, intended to be provided by future releases of the pipeline; this section of the document is a placeholder for the description of the data product.

3.7 Exposure map

This data product is described in a separate ICD (Applicable Document 14).

3.8 Aspect histogram

This data product will be described in a separate ICD.

3.9 PI spectra of target and N (TBD) brightest sources

As of 11/12/1998 , Level 2 pipeline does not provide the PI spectra. They are, however, intended to be provided by future releases of the pipeline; this section of the document is a placeholder for the description of the data product.

3.10 Light curves of target and N (TBD) brightest sources

As of 11/12/1998 , Level 2 pipeline does not provide the light curves. They are, however, intended to be provided by future releases of the pipeline; this section of the document is a placeholder for the description of the data product.