AXAF Science Center

Development and Operations Science Support

Data Product Interface Document: *ASPSOL*

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Document and Change Control Log			
Date	**Version**	**Section**	**Status**
04/04/98	0.1	all	Initial draft
05/04/98	0.2	all	Tom Aldcrofts comments included
06/08/98	1.1	all	Comments from AR, JCM, JHK; Updated HDU kewords and contents of binary table.
06/24/98	1.2	all	Changed to one data product called ASPSOL for both Kalman and Photo method. Added the keywords to Principal HDU: ASPTYPE (Sol. method Kalman/Photo) and BIASTYPE (Kalman/OBC). Changed keywords to start with ra, dec, roll prefixes. Changed bias_rate, and bias_rate_err to three components.
07/01/98	1.3	signed all	
07/23/98	2.0	all	Added sim_x, sim_y, sim_z, pitchamp, yawamp header keywords.
10/9/98	2.1	all	Added aspalg header keyword added file name definitions Deleted TTFORM* = '1D '
10/16/98	2.2	all	T. Aldcroft's comments:
		4.4	Changed keywords to Principal HDU: DETNAM='ACA-P' to ' '
		4.4	Added CONTENT ASPSOL_KAL and ASPSOL_PHO INSTRUME='ACA ' to 'PCAD '
		4.4	Added back TTFORM* = '1D '
11/24/98	2.3	all	Corrected file name definitions
12/01/98	2.4	all	Included additional A. Rots comments
		2	Changed ASC-FITS-1.1 to ASC-FITS-1.3
		4	Replaced keyword DTASPSOL by TIMEDEL
		4	Delete keywords: ONTIME, LIVETIME, STARTMJF, STARTMNF, STOPMJF, STOPMNF
		4	Add keywords: BTIMNULL, BTIMRATE, BTIMDRFT, BTIMCORR

Contents

1 Summary

This document describes the data product ASPSOL which is generated by the following ASC tools: *asp_solve*. ASPSOL contains records of the Kalman- or photo-method based aspect solution as a function of time. In addition to the records of RA, DEC, and roll, and SIM $\Delta y, \Delta z, \Delta\theta$ of (and errors) it also records the attitude quaternions and Kalman bias spacecraft rate.

Tool requirements are from document SE03 and design from document DS01. Data product requirements are from document SDS02 and will conform to FITS standards and conventions described in documents NOST 100-1.1, OGIP93-001, and ASC-FITS-1.3, and coordinate conventions in document SDS01-4.2. (see Applicable Documents). As described in these documents, 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.

2 Applicable Documents

Document	**Description**
SDS01	AXAF Data Products Guide `http://hea-www.harvard.edu/~jcm/asc/docs/ps/SDS01.ps`
SDS02-4.2	AXAF Coordinate Systems `http://hea-www.harvard.edu/~jcm/asc/docs/ps/SDS02.ps`
ASC AMO-2400 (SE03)	ASC Data System Requirements (ASC.302.93.0008)
ASC AMO-2401 (DS01)	ASC Data System Software Design (ASC.500.93.0006)
NOST 100-1.1	Definition of the Flexible Image Transport System (FITS) `http://www.cv.nrao.edu/fits/`

OGIP 93-001	HEASARC FITS Standards:
	`http://legacy.gsfc.nasa.gov/docs/heasarc/ofwg/`
	`docs/summary/ogip_93_001_summary.html`

ASC-FITS-1.3	ASC FITS File Designers' Guide `http://hea-www.harvard.edu/~arots/asc/fits/ascfits.ps`

Tool specs can be found in the ASC SDS Toolbook: http://hea-www.harvard.edu/asclocal/sds/sds.html. The data model shall be included at a later revision.

3 Introduction

3.1 Data product Summary

- Data Product name: ASPSOL
- Tool names: *asp_solve*
- Tool usage: *Level 1 Pipeline, user analysis*

- Tool description: *Following are the tools that contribute to ASPSOL data product*:

  1. asp_solve -

  Asp_solve calculates the motion of the fid light field to obtain the motion of the X-ray detectors with 0.25625 s time-resolution. Writes to ASPSOL: Solution type (Kalman/Photo, Bias type (determined by Kalman or OBC), Nominal record delta-time, nominal pointing. Also writes the aspect solution: RA, DEC, Roll, errors for each vs. time; dY, dZ, and dTheta of STF frame to FC frame, and errors vs. time. Writes records of the attitude quaternion vs. time. and Kalman or OBC bias rates and bias rate errors vs. time.

- Data product file names: The data files shall be assigned external names that obey the following convention: `pcad`*ftv_contentl*`.fits` where `pcad` specifies that this is a pcad file. The *f* is for the data source of the aspect solution: e.g. *k* (for kalman filter/smoother solution), *o* (On-board (OBC) PCAD solution) *p* (Photo-method solution). The other standard options (see e.g. Sec. 2.1 in the L0.5 SIM ICD) would also apply, with the exception of "f" for flight. The *t* is the start time (TSTART- integer part) of the Aspect Interval in which the data were taken, *v* is the processing run (version: N), *content* indicates the contents of the file *asol* (aspect solution), and *l* is 1, for level 1 processing.

- This data product is known to be used by at least the following tools: *asp_make_qualint, X-ray L1 processing.*

4 Data Product: *ASPSOL*

The HDUs are listed below, together with the values of the EXTNAME/HDUNAME, CONTENT, and HDUCLASS/HDUCLAS1/HDUCLAS2 keywords. The ASC principal HDU is indicated with a (*). See ASC-FITS-1.3 for summary of recommended conventions and header structure.

HDU No	Type	EXTNAME	CONTENT
1	Null	-	-
2	BINTABLE (*)	ASPSOL	ASPSOL

4.1 Size estimate

The ASPSOL principal HDU has NAXIS1= 124 bytes per record. The size of the file is (NAXIS1 * rate) *T byte The rate is the temporal rate of $(0.25625^{-1})s^{-1}$, and T is the observation time in seconds. For 100 ks the size is 4.8 MByte.

4.2 *ASPSOL* table: Special Header Keywords

In addition to the header keywords specified in ASC-FITS-1.3, the *ASPSOL* table contains the following keywords:

Principal Header Keywords				
Header	Type	Comment	Units	Dims
ra_nom	double	Nominal pointing RA	deg	
dec_nom	double	Nominal pointing dec	deg	
roll_nom	double	Nominal pointing roll	deg	
asptype	char	Solution method (kalman—photo)		FLEN_VALUE
biastype	char	Gyro bias type (kalman—obc)		FLEN_VALUE
sim_x	float	Reference SIM X position	mm	
sim_y	float	Reference SIM Y position	mm	
sim_z	float	Reference SIM Z position	mm	
pitchamp	float	Obs'd dither pitch amplitude	deg	
yawamp	float	Obs'd dither yaw amplitude	deg	
aspalg	char	Solution algorithm (PSF—FM)		FLEN_VALUE

4.3 *ASPSOL* table: columns

The contents of the binary table are described in the following table.

Binary Table Extension				
Header	Type	Comment	Units	Size
time	double	Time	s	
ra	double	RA of MNC frame (x-axis)	deg	
dec	double	DEC of MNC frame (x-axis)	deg	
roll	double	ROLL of MNC frame	deg	
ra_err	float	Uncertainty in RA	deg	
dec_err	float	Uncertainty in DEC	deg	
roll_err	float	Uncertainty in ROLL	deg	
dy	float	dY of STF frame - FC frame	mm	
dz	float	dZ of STF frame - FC frame	mm	
dtheta	float	dTHETA of STF frame - FC frame	deg	
dy_err	float	Uncertainty in dY	mm	
dz_err	float	Uncertainty in dZ	mm	
dtheta_err	float	Uncertainty in dTHETA	deg	
q_att	double	S/C attitude quaternion		4
roll_bias	float	Roll bias rate	deg/s	
pitch_bias	float	Pitch bias rate	deg/s	
yaw_bias	float	Yaw bias rate	deg/s	
roll_bias_err	float	Roll bias rate error	deg/s	
pitch_bias_err	float	Pitch bias rate error	deg/s	
yaw_bias_err	float	Yaw bias rate error	deg/s	

- The following data model keywords are added: *None*

- The following coordinate systems are added: *None*

4.4 Example File Header

Primary header keywords

```
SIMPLE  =                    T  /  FITS STANDARD
BITPIX  =                   32  / number of bits per data pixel
NAXIS   =                    0  /  No image data array present
EXTEND  =                    T  /  There may be standard extensions
```

```
COMMENT
COMMENT########## Configuration control keywords (short version) ##########
COMMENT
ORIGIN  = 'ASC     '
CREATOR = 'asp_solve - Version 0.0'
CHECKSUM= '0000000000000000'   / ASCII encoded HDU checksum
DATASUM = '         0'         / Data unit checksum written in ASCII
COMMENT
COMMENT########## Timing info keywords (short version) ##########
COMMENT
DATE    = '1998-01-01T01:00:00'/ Date and time of file creation
DATE-OBS= '1998-01-01T00:00:00'/ TT, with clock correction if CLOCKAPP
DATE-END= '1998-01-01T01:00:00'/ TT, with clock correction if CLOCKAPP
TIMESYS = 'TT      '           / AXAF time will be TT (Terrestrial Time)
MJDREF  =                50814 / 1998-01-01T00:00:00 (TT) expressed in MJD
TIMEZERO=                  0.0 / 0.0 is the cumulative clock correction
TIMEUNIT= 's       '
CLOCKAPP=                    T / Clock correction applied
TSTART  =                  0.0 / As in the "TIME" column: raw S/C clock
TSTOP   =                  0.0 / add TIMEZERO and MJDREF for absolute TT
COMMENT
COMMENT########## Observation info keywords (short version) ##########
COMMENT
MISSION = 'AXAF    '            / Advanced X-Ray Astrophysics Facility
TELESCOP= 'AXAF    '            / Telescope used
INSTRUME= 'PCAD    '            / PCAD
DETNAM='        '               / detector
OBS_ID  = 'RX-EE-1.001A'        / Observation ID
COMMENT
COMMENT########## Terminating END keyword ##########
COMMENT
END
```

Principal HDU keywords

```
XTENSION= 'BINTABLE'           / binary table extension
BITPIX  =                    8 / 8-bit bytes
NAXIS   =                    2 / 2-dimensional binary table
NAXIS1  =                  124 / width of table in bytes
NAXIS2  =                  377 / number of rows in table
PCOUNT  =                    0 / size of special data area
GCOUNT  =                    1 / one data group (required keyword)
TFIELDS =                   20 / number of fields in each row
EXTNAME = 'ASPSOL  '            / name of this binary table extension
COMMENT
COMMENT########## Configuration control keywords ##########
COMMENT
ORIGIN  = 'ASC     '
CREATOR = 'xxx - Version 0.0'
ASCDSVER= 'R4C2.0'
REVISION=                    0 / Processing system revision number
COMMENT $Id$
CHECKSUM= '0000000000000000'   / ASCII encoded HDU checksum
DATASUM = '         0'         / Data unit checksum written in ASCII
CONTENT = 'ASPSOL     '           / What data product
HDUNAME = 'ASPSOL     '           / If no EXTNAME
HDUDOC  = 'ASC-FITS-1.3: McDowell, Rots: ASC FITS File Designers Guide'
HDUVERS = '1.0.0   '
HDUCLASS= 'ASC     '
HDUCLAS1= 'TEMPORALDATA'
HDUCLAS2= 'ASPSOL'
LONGSTRN= 'OGIP 1.0'           / The OGIP long string convention may be used.
COMMENT
COMMENT########## Timing info keywords ##########
COMMENT
DATE    = '1998-01-01T01:00:00'/ Date and time of file creation
DATE-OBS= '1998-01-01T00:00:00'/ TT, with clock correction if CLOCKAPP
DATE-END= '1998-01-01T01:00:00'/ TT, with clock correction if CLOCKAPP
TIMESYS = 'TT      '           / AXAF time will be TT (Terrestrial Time)
MJDREF  =                50814 / 1998-01-01T00:00:00 (TT) expressed in MJD
TIMEZERO=                  0.0 / 0.0 is the cumulative clock correction
TIMEUNIT= 's       '
TIMEREF = 'LOCAL   '           / No pathlength corrections
TASSIGN = 'SATELLITE'          / Spacecraft clock
BTIMNULL=                  0.0 /Basic Time offset (s)
BTIMRATE=              0.25625 /Basic Time clock rate (s/VCDUcount)
BTIMDRFT=                  0.0 /Basic Time drift (s/VCDUcount^2)
BTIMCORR=                  0.0 /Correction applied to Basic Time Rate (s)
CLOCKAPP=                    T / Clock correction applied
TIERRELA=               1.0E-9 / Short-term clock stability
TIERABSO=               1.0E-4 / Absolute precision of clock correction
TIMVERSN= 'ASC-FITS-1.3'       / AXAF FITS design document
TSTART  =                  0.0 / As in the "TIME" column: raw S/C clock
TSTOP   =                  0.0 /   add TIMEZERO and MJDREF for absolute TT
TIMEDEL =              0.25625 / Time resolution of data (in seconds)
TIMEPIXR=                  0.0 / Time stamp
COMMENT
```

```
COMMENT########## Observation info keywords ##########
COMMENT
MISSION = 'AXAF    '            / Advanced X-Ray Astrophysics Facility
TELESCOP= 'AXAF    '            / Telescope used
INSTRUME= 'PCAD    '            / Aspect Camera
DETNAM  = '        '            / Detector
GRATING = 'NONE    '            / HETG, LETG or NONE
OBJECT  = '        '            / Source name
TITLE   = '        '            / Title of Observation
OBSERVER= 'A. Scientist'        / Observer or PI
OBS_ID  = 'RX-EE-1.001A'        / Observation ID
RA_NOM  =                    0. / Nominal RA in degrees
DEC_NOM =                    0. / Nominal Dec in degrees
ROLL_NOM=                    0. / Nominal Roll in degrees
EQUINOX =                2000.0 / J2000.0
RADECSYS= 'ICRS    '            / Julian coordinate reference frame
DATACLAS= 'OBSERVED'            / default is 'OBSERVED'
ASPTYPE = 'kalman   '           / Solution method (kalman|photo)
BIASTYPE= '        '           / Gyro bias type (kalman|obc)
EQUINOX = '        '           / Coordinate system equinox
SIM_X   = '    0.0 '           / Reference SIM X position
SIM_Y   = '    0.0 '           / Reference SIM Y position
SIM_Z   = '    0.0 '           / Reference SIM Z position
PITCHAMP= '    0.0 '           / Obs'd dither pitch amplitude
YAWAMP  = '    0.0 '           / Obs'd dither yaw amplitude
ASPALG  = '        '           / Solution algorithm (PSF|FM)
COMMENT
COMMENT########## Column format info ##########
COMMENT
TTYPE1  = 'time    '           / Time
TFORM1  = '1D      '           / data format of field: 8--byte DOUBLE
TUNIT1  = 's       '           / physical unit of field
TTYPE2  = 'ra      '           / RA of MNC frame (x-axis)
TFORM2  = '1D      '           / data format of field: 8--byte DOUBLE
TUNIT2  = 'deg     '           / physical unit of field
TTYPE3  = 'dec     '           / DEC of MNC frame (x-axis)
TFORM3  = '1D      '           / data format of field: 8--byte DOUBLE
TUNIT3  = 'deg     '           / physical unit of field
TTYPE4  = 'roll    '           / ROLL of MNC frame
TFORM4  = '1D      '           / data format of field: 8--byte DOUBLE
TUNIT4  = 'deg     '           / physical unit of field
TTYPE5  = 'ra_err  '           / Uncertainty in  RA
TFORM5  = '1E      '           / data format of field: 4-byte REAL
TUNIT5  = 'deg     '           / physical unit of field
TTYPE6  = 'dec_err '           / Uncertainty in  DEC
TFORM6  = '1E      '           / data format of field: 4-byte REAL
TUNIT6  = 'deg     '           / physical unit of field
TTYPE7  = 'roll_err'           / Uncertainty in  ROLL
TFORM7  = '1E      '           / data format of field: 4-byte REAL
TUNIT7  = 'deg     '           / physical unit of field
TTYPE8  = 'dy      '           / dY of STF frame - FC frame
TFORM8  = '1E      '           / data format of field: 4-byte REAL
TUNIT8  = 'mm      '           / physical unit of field
```

```
TTYPE9  = 'dz      '            / dZ of STF frame - FC frame
TFORM9  = '1E      '            / data format of field: 4-byte REAL
TUNIT9  = 'mm      '            / physical unit of field
TTYPE10 = 'dtheta  '            / dTHETA of STF frame - FC frame
TFORM10 = '1E      '            / data format of field: 4-byte REAL
TUNIT10 = 'deg     '            / physical unit of field
TTYPE11 = 'dy_err  '            / Uncertainty in dY
TFORM11 = '1E      '            / data format of field: 4-byte REAL
TUNIT11 = 'mm      '            / physical unit of field
TTYPE12 = 'dz_err  '            / Uncertainty in dZ
TFORM12 = '1E      '            / data format of field: 4-byte REAL
TUNIT12 = 'mm      '            / physical unit of field
TTYPE13 = 'dtheta_err'          / Uncertainty in dTHETA
TFORM13 = '1E      '            / data format of field: 4-byte REAL
TUNIT13 = 'deg     '            / physical unit of field
TTYPE14 = 'q_att   '            / S/C attitude quaternion
TFORM14 = '4D      '            / data format of field: 8-byte DOUBLE
TTYPE15 = 'roll_bias'           / Roll bias rate
TFORM15 = '1E      '            / data format of field: 4-byte REAL
TUNIT15 = 'deg/s   '            / physical unit of field
TTYPE16 = 'pitch_bias'          / Pitch bias rate
TFORM16 = '1E      '            / data format of field: 4-byte REAL
TUNIT16 = 'deg/s   '            / physical unit of field
TTYPE17 = 'yaw_bias'            / Yaw bias rate
TFORM17 = '1E      '            / data format of field: 4-byte REAL
TUNIT17 = 'deg/s   '            / physical unit of field
TTYPE18 = 'roll_bias_err'       / Roll bias rate error
TFORM18 = '1E      '            / data format of field: 4-byte REAL
TUNIT18 = 'deg/s   '            / physical unit of field
TTYPE19 = 'pitch_bias_err'      / Pitch bias rate error
TFORM19 = '1E      '            / data format of field: 4-byte REAL
TUNIT19 = 'deg/s   '            / physical unit of field
TTYPE20 = 'yaw_bias_err'        / Yaw bias rate error
TFORM20 = '1E      '            / data format of field: 4-byte REAL
TUNIT20 = 'deg/s   '            / physical unit of field
COMMENT
COMMENT########## Terminating END keyword ##########
COMMENT
END
```