ASC Data Products Guide: SDS-1.0

Jonathan McDowell

February 26, 1998

This document is a revision of the material in the data products chapter of the ASC Requirements document, SE03.

1 ASC Data Products

1.1 Standard Data Processing

1.1.1 Standard Data Processing Overview

Standard Data Processing (SDP) performs automated, on-line standard reduction and analyses of data gathered during an X-ray observation to provide data products which are useful, to the widest possible range of observers, as initial indications of the observation's scientific content and as bases for more detailed, refined, and customized off-line analysis using the capabilities specified in section **??**. A common set of software tools (section **??**) is used for both the on-line and off-line analysis.

The Standard Data Products are produced at four processing levels – Level 0 through Level 3. Level 0 Products consist of Level 0 Telemetry and Ancillary Data (see section **??**) applicable during the observation intervals and are provided to the user upon request. Level 0 Products preserve all information available in the original data and provide the basis for the higher-level products. The Level 0-3 Products are summarized in Tables 5.4-4 and **??**. Table 5.4-4 shows the data products which are produced for all observations, regardless of the science instrument used. Table **??** shows, by instrument, the Level 2 products which are produced in addition to those in Table 5.4-4. Descriptions of each standard product are provided in glossary form by Table 5.4-5. Details about each product's contents are provided by Tables 5.4-7 through 5.4-9. All quantities derived during standard processing have their uncertainties estimated and are supplied as part of the data. All calibration information used to perform any corrections during standard processing form an integral part of the Standard Products. All calibration data is maintained current based on measured spacecraft/SI performance (section **??**).

Full data accountability, processing history, and version histories are maintained throughout all levels of standard processing. The resulting processing logs provide both the user and the ASC staff with full visibility into each step of the standard reduction and analysis. The logs contain data and version history sufficient to exactly reproduce the original standard processing at any time in the future. Standard processing is expected to operate under the routine supervision of an ASC data technician with scientist supervision and review to handle special problems.

1.1.1.1 Processing Control Overview The ASCDS archives accumulated Level 0 telemetry as the original Merged Telemetry is received. Level 1 processing is performed, to the extent possible, on the received data intervals. For a given observation, when the received data intervals sum approximately to the observing time, the ASCDS requests final Level 1 and Level 2 processing for that observation. If a time interval (nominally one month) has elapsed prior to collecting all the observation data, the ASCDS automatically requests Level 1 and Level 2 processing (to the extent possible) for the pointings accumulated so far. The ASC staff can view telemetry accumulation summaries and manually request SDP of an observation part (a single pointing or a set of accumulated pointings) at any time for any observation. Once requested, the processing of a single interval of data will hereafter be referred to as an *SDP job*. The ASC staff can, at any time, view the active and pending SDP jobs and reprioritize, suspend, restart, or cancel

Table 5.4-4: Standard AXAF Data Products: All Instruments

Data Product	**Level**	**Delivery**
Observation Description Products		
Telemetry Data	0	On Request
Housekeeping and Spacecraft Data		
Observation Table	1	Routine
Temporal Status Intervals	1	Routine
Orbital Ephemeris Table	1	Routine
Sun Angle Table	1	On Request
Solar System Ephemeris	1	On Request
Housekeeping Status Changes	1	Routine
Event Rates Table	1	Routine
Aspect Solution Data		
Aspect Solution	1	Routine
Aspect Quality	1	Routine
Aspect Solution Histogram	1	Routine
Stable Aspect Intervals	1	Routine
Field Data		
Field Source Catalog	1	Routine
Field Diffuse Emission Catalog	1	Routine
Field Multiwaveband Image	1	Routine
Processing Information		
Observation Summary	2	Routine
SDP Profile	2	Routine
SDP Log	2	Routine
Aspect Solution Secondary Products		
Guide Star Properties	1	On Request
Guide Star Observations	1	On Request
Guide Star Usage	1	On Request
ACA Data	1	On Request
ACA Bad Pixel Map	1	On Request
ACA Flat Field	1	On Request
ACA Dark Current Image	1	On Request
ACA Field Distortion Table	1	On Request
ACA Sub Pixel Response Map	1	On Request
ACA Misalignment	1	On Request
ACA Stellar PSF	1	On Request

ACA Fid Light PSF	1	On Request
ACA Read Noise Calibration Table	1	On Request
ACA Color Magnitude Correction Table	1	On Request
Gyro Data	1	On Request
Gyro Calibration Data	1	On Request
Gyro Status History	1	On Request
Gyro Rotation Angles	1	On Request
Fid Light Calibration	1	On Request
ACA Sightings	1	On Request
ACA Kalman Data	1	On Request
ACA Photo Centroids	1	On Request
Image Motion Correction	1	On Request
Reference Aspect Solution	1	On Request
X-ray Data Calibration Products		
Vignetting Map	1	Routine
Ancillary Response File	1	Routine
Redistribution Matrix File	1	Routine
QE Uniformity Map	1	Routine
PSF Models	1	Routine
PSF Size Table	1	Routine
Background Model	1	Routine
X-ray Basic Data Products		
Level 1 Photon List	1	Routine
For each PI band:		
Sky Image	1	Routine
Detector Image	1	Routine
Exposure Map	1	Routine
Effective Exposure Map	1	Routine
Effective Exposure Map	1	Routine
Predicted Background Map	1	Routine
Background Map	2	Routine
Next-In-Line SI Photons	1	On Request
Level 2 Photon List	2	Routine
Source List	2	Routine
Source Detection Processing Summary	2	Routine
Source Analysis Products		

For each detected source: Source Photon Filter	2	Routine
Source Properties	2	Routine
Source Flux Table	2	Routine
Source Pulse Height Spectrum	2	Routine
Source Light Curve	2	Routine
Source Light Curve Power Spectrum	2	Routine
Local Background Photon Filter	2	Routine
Local Background Pulse Height Spectrum	2	Routine
Local Background Light Curve	2	Routine
Source Cross-ID Table	2	Routine
Source Ancillary Response File	2	Routine
Source Redistribution Matrix File	2	Routine
Background Photon Filter	2	Routine
Background Pulse Height Spectrum	2	Routine
Background Light Curve	2	Routine
Grating Data Products (HETGS,LETGS only)		
TG Vignetting Map	2	Routine
Zero Order Image	2	Routine
Spectrum List	2	Routine
For each detected spectrum: High-Resolution Spectrum	2	Routine
Spectrum Properties	2	Routine
Spectrum RMF	2	Routine
Spectrum ARF	2	Routine
Spectral Exposure Map	2	Routine
Spectral Effective Exposure Map	2	Routine
Spectral Effective Area Map	2	Routine
Spectrum Local Background	2	Routine
Spectrum Local Background ARF	2	Routine
Spectrum Local Background Exposure Map	2	Routine
Spectrum Local Background Effective Exposure Map	2	Routine
Spectrum Local Background Effective Area Map	2	Routine
Spectral Line Feature Table	2	Routine
Catalog Products		
AXAF Observation List	3	On Request
AXAF Pointing Catalog	3	On Request
AXAF Candidate Source Catalog	3	On Request
AXAF Source Catalog	3	On Request

AXAF Spectral Catalog	3	On Request
AXAF Source Bibliographic Catalog	3	On Request
AXAF Bibliography	3	On Request
AXAF Identifications and Cross-Ref Catalog	3	On Request
AXAF Object Class List	3	On Request
AXAF Class Catalog	3	On Request
AXAF Images In Region	3	On Request
Sky Coverage Map	3	On Request
Selected Region List	3	On Request
Selected Region File	3	On Request
Selected Region Mosaics	3	On Request
Slew Photon Lists	3	On Request
Diffuse Background Maps	3	On Request

Table 5.4-5: Standard Data Product Glossary

ACA Bad Pixel Map - Map of bad pixels in Aspect Camera.

ACA Color Magnitude Correction Table - Calibrated corrections to Aspect Camera counts and positions as a function of guide star color.

ACA Dark Current Image - Aspect Camera dark current calibration image.

ACA Data - Aspect Camera raw image extracts and calculated centroids for each exposure.

ACA Field Distortion Table - Geometric distortion as a function of Aspect Cameral pixel position.

ACA Flat Field - Sensitivity variations across Aspect Camera CCD.

ACA Kalman Data - Results of Kalman filter combination of aspect camera and gyro data.

ACA Misalignment - Calibration of aspect camera optical misalignments.

ACA Photo Centroids - Intermediate star and fid light centroid positions, for ACA exposures grouped into 'photos'.

ACA PSFs, Stellar and Fid Light - Point Spread Functions for stars and fiducial lights imaged by the Aspect Camera, modelled for each star and fid light.

ACA Read Noise Calibration Table - Calibration of read Noise versus engineering parameters for the Aspect Camera CCD.
ACA Sightings - Calibrated Aspect Camera star and fid light centroid positions and magnitudes as a function of time.

Table 5.4-5: Standard Data Product Glossary (continued)

ACA Sub Pixel Response Map - Calibration of sub pixel sensitivity response versus position for Aspect Camera CCD.

Ancillary Response File (ARF) - Multiplicative components of energy response, as a function of energy, giving effective area normalization.

Aspect Solution - Celestial pointing/roll angles and image motion correction (in tangent plane pixel coordinates) as a function of time.

Aspect Solution Histogram - Binned aspect solution as a fraction of the observation livetime, used to apply detector coordinate calibration maps to the sky image.
AXAF Bibliography - Bibliographic references to results based on AXAF observations.

AXAF Candidate Source Catalog - List of candidate sources detected by each standard processing, without matching performed between observations. A rawer product than the AXAF Source Catalog.

AXAF Class Catalog - AXAF sources and upper limits by source class. Example source classes are: Solar system; Stellar coronal sources; sub-classes O, B, A, F, G, M, K, C, WD; T_Tauri; White dwarf/Neutron star/Black hole systems; Supernovae; Supernovae remnants; Pulsars; Star formation regions; Galaxies by sub-classes Irr, Sa, Sb, Scd, S0, E, starburst; Groups, clusters of galaxies; AGN and quasars by sub-classes BL Lacs, Seyferts, + others.

AXAF Identifications and Cross-Reference Catalog - AXAF source designations and upper limits for objects in non-AXAF catalogs. Example catalogs are: IRAS PSF, FSC; 87BG & PKS extension; SAO (star) catalog; Uppsala/ESO galaxy catalogs; Veron Quasar/AGN catalog; Abell, Corwin, & Olowin cluster catalogs); source identification information from the literature via SIMBAD and NED.

AXAF Images in Region - Derived data product listing all AXAF data overlapping given sky region or including given position.

AXAF Object Class List - List of the defined source classes.

AXAF Observation List - List of all observations made with AXAF. Compilation of data from all Observation Summaries.

AXAF Pointing Catalog - List of all pointings made by AXAF. Serves as a quick reference for identifying images and exposure time within a designated region of the sky.

AXAF Source Catalog - Summary information on all confirmed (high probability) sources observed by AXAF, including properties. Identifies multiple observations of the same source and assigns AXAF-unique designations to sources.

AXAF Source BibliograPIc Catalog - BibilograPIc information collected by source.

Table 5.4-5: Standard Data Product Glossary (continued)

AXAF Spectral Catalog - Summary information on all high-resolution spectra produced by AXAF and their characteristics (fits, line/edge detections, parameter lists).

Background Light Curve - Same as Source Light Curve, but for the image background after source removal.

Background Map - Background counts over the image grid after source removal (one for each image).

Background Model - Instrument-internal, solar, galactic, extragalactic, particle, and summed expected background over the field.

Background Photon Filter - Mask for photons corresponding to the image background after source removal.

Background Pulse Height Spectrum - Binned PI spectrum from image background after source removal.

Detector Image - Map of detected photons in PI band versus detector coordinates.
Diffuse Background Maps - Maps of composite background, background spectra, etc. generated from multiple observations.

Effective Area Map - Effective sensitivity times collecting area (corrected for instrument effects and vignetting) as a function of position, energy, within the detector field of view (one map for each image).

Effective Exposure Map - Exposure time (corrected for instrument effects and vignetting) as a function of position, energy, within the detector field of view (one map for each image).

Event Rates Table - Summary of primary and secondary science event count rates, field and background count rates, versus time.

Exposure Map - Exposure time as a function of position, without corrections.

Fid Light Calibration - Positions of each Fid Light in SIM table coordinates, and nominal positions in aspect camera coordinates.

Field Diffuse Emission Catalog - Sky survey image maps/values for field: Galactic NH (21 cm), Hα, CO, HI with velocity information.

Field Multiwaveband Image - Optical sky survey digitizations of the observed field of view. POSS/UKS; IRAS-FSS; Radio-87GB; IR cirrus; ROSAT.

Field Source Catalog - Lists of cataloged objects in field.

Table 5.4-5: Standard Data Product Glossary (continued)

Guide Star Observations - Observed properties of guide stars derived from ACA data processing.

Guide Star Properties - Extract from the AXAF Guide Star Catalog giving the relevant properties of all guide stars used or attempted for this observations.

Guide Star Usage - Guide stars used as a function of time.

Gyro Calibration Data - Bias and scale factors for each gyro used.

Gyro Data - Raw gyro count behaviour versus time.

Gyro Rotation Angles - Spacecraft motion solution based on gyro data only.

Gyro Status History - Gyros in use as a function of time.

High-Resolution Spectrum - Spectrum, region background (both separated by PI bin into orders for the ACIS), and calibrated spectrum (summed by side and order for the ACIS), background-subtracted. Calibrated to counts/bin/sec, corrected to energy/wavelength scale, local quantum efficiency, gain, and (for ACIS) spectral resolution.

Housekeeping Status Changes - Changes in housekeeping status parameters for SI and spacecraft, versus time.

Image Motion Correction - Relative motion of sky, X-ray image and aspect camera frames versus time.
Local Background Light Curve - Same as Source Light Curve, but for the local background.

Local Background Photon Filter - Photons corresponding to the local background region.

Local Background Pulse Height Spectrum - Binned PI local background spectrum.

Observation Summary - Target parameters, active detector, FPSI position/focus, active grating, ACIS operating mode and submode, live time correction factors, number of sources detected, target detected (yes/no), background rate, center-of-field exposure time, center-of-field upper limit and threshold number of counts for each energy band, dead time, SI/subsystem anomaly reports. Plots of image field and summary of sources detected.

Observation Table - List of individual pointings making up the observation.

Orbital Ephemeris Table - Spacecraft position versus time.

Table 5.4-5: Standard Data Product Glossary (continued)

Photon List - Photon event file consisting of all photons in the observation. Corrected for aspect and instrument effects to celestial coordinates. Calibrated for instrument effects to true energy/pulse height. Identified as to validity and whether received during a "good" observing interval. Good-times are based on standard criteria used to optimize the observation for a "typical" observer, *e.g.,* minimize background by avoiding solar fluorescence off the Earth's atmosphere. Level 1 Photon List contains basic information on all photons. Level 1.5 Photon List adds information from transmission grating order sorting analysis. Level 2 Photon List contains only good photons and incorporates some source information from source detection processing. Next-In-Line SI Photon List contains Level 1 class information on events detected by the next in line science instrument.

Predicted Background Map - Predicted background counts in the PI band versus image pixel position.

PSF Models - Point Spread Function information as a function of energy.
PSF Size Table - Single parameter describing size of point spread function, as a function of detector position and energy.
QE Uniformity Map - Map of detector sensitivity as a function of position.

Redistribution Matrix File - probability distribution for photon pulse heights as a function of energy.

Reference Aspect Solution - Aspect solution at reference time for each observation interval.

SDP Log - Data processing history, software version numbers, bug reports.

SDP Profile - Data Processing profile used for this set of data products.

Selected Region File - For regions of special interest, definition of the sky extent of the region. See Selected Region Mosaics.

Selected Region List - List of regions of special interest. See Selected Region Mosaics.

Selected Region Mosaics - Mosaics of AXAF observations covering particularly interesting areas on the sky (e.g. M31, Orion, Galactic Center, Virgo).

Sky Coverage Map - for statistical population studies. Contains sensitivity as a function of solid angle covered, extractable for arbitrary sets of AXAF HRC/ACIS observations and regions within observations.

Sky Image - X-ray image for each detector pulse height invariant (PI) band (1 for the HRC, 10 for the ACIS) formed from "good" photons (includes strong lines/across edges for the ACIS).

Slew Photon Lists - Photons detected while the spacecraft was slewing.

Table 5.4-5: Standard Data Product Glossary (continued)

Solar System Ephemeris - Position of planets versus time for this observation, used for barycenter corrections.

Source ARF - Source Ancillary Response File. ARF appropriate for source region, derived from source position and ARF calibration.

Source Cross-ID Data - Possible source counterparts from sky surveys. Multi-wavelength fluxes. Probable source types given $L_x/L(other)$, $f_x/f(other)$. NED, SIMBAD search references.

Source Detect Processing Summary - Detailed algorithm-specific results of detect processing, giving parameters of detected sources at different cell scales and bands.

Source Flux Table - Source fluxes in different bands.

Source Light Curve - Binned light curve of source photons.

Source Light Curve Power Spectrum - Power spectrum of source light curve.

Source List - Summary of detected sources, including detection method, significance, source and local background regions.

Source Photon Filter - Mask for photons corresponding to the source region.

Source Properties - Flux, position, extent, colors, hardness ratios, simple spectral fits, variability, period. Includes photometric results for the target, if available.

Source Pulse Height Spectrum - Binned PHA source spectrum.

Spectral Effective Area Map - Effective Area Map versus dispersion coordinate for extracted high resolution spectrum.

Spectral Effective Exposure Map - Effective Exposure Map versus dispersion coordinate for extracted high resolution spectrum.

Spectral Exposure Map - Exposure Map versus dispersion coordinate for extracted high resolution spectrum.

Spectral Line Feature Table - Line fits parameters for high resolution spectrum. Line or edge central energy/wavelength, flux, or fractional rise/fall, width (energy/wavelength, velocity), shape parameters plus order.

Spectrum ARF - ARF for extracted dispersed spectrum, giving effective area components as a function of energy.

Spectrum Local Background - Extracted local background versus dispersion coordinate for a high resolution spectrum.

Spectrum Local Background ARF - ARF for Spectrum background.

Spectrum Local Background Effective Area Map - Effective Area versus dispersion coordinate for Spectrum Local Background.

Spectrum Local Background Effective Exposure Map - Effective exposure, corrected for vignetting and QE, for Spectrum Local Background.

Table 5.4-5: Standard Data Product Glossary (continued)

Spectrum Local Background Exposure Map - Exposure time as a function of dispersion coordinate for the Spectrum Local Background.
Spectrum Properties, source confusion information, Includes cross dispersion spatial properties of the spectrum.

Spectrum RMF - RMF response matrix for transmission grating spectrum.
Stable Aspect Intervals - Binned aspect solution as a function of time, the stable aspect intervals.
Sun Angle Table - Spacecraft to Sun angle versus time.

Telemetry Data - Complete processed telemetry for each observation, decommutated, time-tagged, grouped into a set of time-ordered substreams, and delivered in FITS format.

Temporal Status Intervals - List of intervals in which the standard screening criteria changed their values; definition of standard screening criteria.

TG Vignetting Map - Vignetting of telescope as a function of shell and grating order.
Vignetting Map - Vignetting of telescope versus energy and position.

Zero Order Image - Cumulative counts in spatial bins for zero order photons only, in grating data.

individual jobs. If two separate jobs are to be linked in some way, so that the outputs of one are to affect the inputs or the processing parameters for the other, then their relative priority handles the linking (TBR). For example, if one of the jobs is a calibration observation that is intended to update calibration information to be used in a later job, then the calibration observation must have the higher priority.

SDP conducts limit and other TBD in-line checks to verify that the processing is proceeding satisfactorily. If a job fails TBD in-line checks or hangs in its pipeline, it is automatically suspended (other actions are TBD and possibly severity-based); the suspension status and other TBD indicators as to the reason are displayed to the ASC staff. Processing automatically continues with the next-highest priority pending SDP job. The ASC staff can examine the indicators, processing log, and any results produced from the suspended job. Once the problem has been identified (see section **??**), the ASC staff can modify or substitute the Processing Profile, restart the job from well-defined points within the sequence (including the start and others TBD), or cancel the job.

When an SDP job executes, it uses setup and processing parameters expressed in a Processing Profile. All science observations are processed using a Standard (default) Profile. A Processing Profile consists of a "script" which defines sequence and configuration of the processing to execute, links to all necessary calibration models and parameters, the limits to use in SDP self-checks (TBR), and any other parameters required by each constituent process. All science observations are processed using a *Standard* (default) Profile. The ASC staff and the user have the option to request that additional, individualized processing be performed by specifying a separate Processing Profile for the observation or data interval (see section 1.1.1.5). Only the ASC staff can view and modify the Standard Profile, though users have access to copies of it. The Standard Profile configures the automated sequence of Level 1 through Level 2 processing, the sequence is performed, and the Level 1 and Level 2 Products listed in Tables 5.4-7 and 5.4-8 are produced. If the job completes successfully, its status is logged and the resulting data products are archived. The overall quality of the products is evaluated relative to scientific expectations as described in section **??**.

Table 5.4-6: AXAF Standard Header Information

Section	Data Items
In distributed FITS files, this is included as header information, the AXAF Standard Header Information incorporated in each FITS file primary header.	
Processing Keywords:	
	Processing system version
	SDP Profile
	Processing number (Number of times processed)
S/C Configuration Keywords:	
	Mission (AXAF)
	Focal Plane Instrument
	detector ID
	grating
	detector modes
	focus
	SIM Position
Observation keywords:	
	Observation ID
	Target name
	Target coordinates
	Start and stop date/time
	Principal Investigator
	Proposal Title
	Requested Time
	Ontime
	Livetime

A standard set of observation information (Table 5.4-6) is compiled by the SDP during Level 1 processing and is included in each Level 1 and Level 2 standard product, so that an isolated standard product is self describing to the extent that it associates the data product with the AXAF mission, a particular proposal and observations, and the processing configuration that produced it. This information will include standard multi-mission information to ensure compatibility with external analysis systems.

An Observation Summary containing overview information about the observation and the processing results is compiled upon SDP completion and forms an integral part of the set of standard products.
The Observation Summary data product is a document as distinct from a scientific data file. It contains science data from the other data products, formatted for easy interpretation. This document takes the place of the paper hardcopy supplied for earlier missions and is available in at least EPS (Encapsulated Postscript) format.
The Summary contains:

- All of the Standard Header information listed above;
- A plot (grey scale) of a smoothed version of the Level 1 Image Array in the broad band, annotated with celestial coordinates and detected sources.
- A summary of the Temporal Status Intervals product.
- A table summarizing the Observation Table product.
- A table summarizing the Source List product.
- A grey scale plot of the Optical Field Image annotated with the information in the Field Catalog.
- A copy of the processing profile and processing summary.

An Observation Index data product contains pointers to all the data products for an observation, allowing user-provided software to identify particular types of data products without having access to the file naming rules. (This also allows users to construct an Observation Index for data for other missions which follow different file naming rules). The Observation Index will map data product types to specific filenames.

1.1.1.2 Level 1 Processing Overview Level 1 Products (Table 5.4-7) are observation results typically based on data gathered over the entire FPSI field of view and observing interval. AXAF users will perform substantial analysis work using products from this level. Principal Level 1 Products are a set of X-ray images (the number of which depends on the FPSI used), created from photon events detected during "good time" subintervals of the total observing interval, and their corresponding exposure maps. The precision Aspect Solution is generated and the Mission Timeline (page 39) is updated. Time slices of both corresponding to the observing intervals are supplied as Level 1 Products. All detected photon events are supplied. These are corrected for instrument distortions to incident pixel positions and for aspect motion to celestial positions and barycentric times. All pulse height, timing, uncorrected pixel positions, and observation information (e.g. which ACIS CCD chip detected the event) are retained at this level. Level 1 Products also include non-AXAF information applicable to the observed field such as N_{HI} (21 cm) information and digitized POSS/UK Schmidt sky survey images.

Level 1 processing is applied to data acquired during all science observations, calibration observations, and during slew periods between observation pointings. The calibration results are archived and provided to the Calibration element. Proprietary rights to the slew results will be governed by AXAF science policies.

Table 5.4-7: Level 1 Standard Data Products

Data Product	Data Items
Housekeeping and Spacecraft Data	
Observation Table	*For each observation interval* Observation Interval names Observation Interval start and stop times Observation Interval start and stop formatted dates Observation Interval pointing directions Observation Interval roll angles Observation Interval duration, ontime, livetime Observation Interval number within observation
Temporal Status Intervals	*Event screening conditions.* *For each time a column value changes* Start time of interval SI at focus SI NIL SI temperature code SI pressure code SI high voltage step Grating in path Datamode Viewing geometry Radiation flag Aspect quality flag Telemetry problem flag
Orbital Ephemeris Table	*For every 10 min of data* Time Solar position vector Lunar position vector AXAF position vector McIlwain parameters OCC time delay AXAF long, lat, height
Sun Angle Table	*For every time angle changes by 10 (TBR) deg* Start, stop time Angle between Sun and nominal pointing direction
Solar System Ephemeris	*For each day of observation; plus 2 days either side* Time Daily Solar position vector Daily Jovian position vector Daily Saturnian position vector

Table 5.4-7: Level 1 Standard Data Products (continued)

Data Product	Data Items
Housekeeping Status Changes	*For each time any value changes* Time SI at focus SI next-in-line SI temperature step SI pressure step SI high voltage Grating in path Instrument mode
Event Rates Table	*For every 10s (TBR)* time background rates total event rates other rates TBD
Field Data	
Field Source Catalog	SIMBAD and x-ray catalogs extract *For each astronomical object* Object name Object RA, Dec and uncertainty Object magnitudes and fluxes Object class Object variability flag Object extent Object alternate names
Field Diffuse Emission Catalog	*1 value for each quantity* HI column Reddening CO HI velocity histogram Hα flux Cirrus code
Field Multiwaveband Image	Stack of other images of field *For each other mission image* *Image is binned to same grid as X-ray image* Mission Instrument Observation ID Image *Includes:* Optical POSS Image
	All X-ray pointed images of field EUVE image of field

Table 5.4-7: Level 1 Standard Data Products (continued)

Data Product	Data Items
	IRAS 100 micron mosaic ROSAT RASS mosaic of field (if available) VLA FIRST survey mosaic of field (if available)
Aspect Solution Data	
Aspect solution	Pointing vs time (RA, Dec, roll, on-axis pixel coords, and uncertainty)
Aspect quality	Times of good quality aspect: Start time, stop time Aspect quality flag Kalman fit quality flag Gyro data quality flag Number of guide stars detected Centroid fit quality flag
Aspect Solution Histogram	Bins of aspect relative to nominal aspect.
Stable Aspect Intervals	Binned aspect intervals *one record per period of stable aspect* Start time, stop time Mean aspect RMS aspect jitter *In header:* Sky region and pixel size (detector-dependent)
Aspect Solution Secondary Products	
Guide Star Properties	*For each guide star used* ID, RA, Dec, V mag, colors, Proper motion, spectral type, multiplicity
Guide Star Observations	*For each guide star used* Derived RA, Dec Instrument mag Spoiler flag Spoiler distance, angle Spoiler instrumental mag
Guide Star Usage	*For each change or loss of guide star* Start time, stop time IDs of Guide stars in use
ACA Data	*For every ACA readout* Time [from telem] Subframe boundaries [from telem] Subframes (stars and fid lights) [raw and corrected] Bad pixel maps [from calib] Camera temperatures [from telem] PSF tables [from calib] Raw centroids Gyro corrected centroids

Table 5.4-7: Level 1 Standard Data Products (continued)

Data Product	Data Items
	Guide star detector positions Guide star + fid light counts
ACA Bad Pixel Map	*For every time map changes* Image of bad pixels in ACA [from calib] *Header data:* Valid time range
ACA Flat Field	 Image of ACA flat field *Header data:* Valid time range
ACA Dark Current Image	 zero-level map[from calib] *Header data:* Valid time range
ACA Field Distortion Table	Distortion polynomial coefficients [from calib] *Header data:* Valid time range
ACA Sub Pixel Response Map	Coarse grid image of mean sub-pixel response (10 x 10 or less) *Header data:* Valid time range
ACA Misalignment	Coordinate transform for ACA to HRMA
ACA Stellar PSF	 Valid time range Type: Grid, interpolated, CTI (Charge Transfer Inefficiency)-corrected Images of star PSFs [from calib] *Header data:* CTI coefficients used (if applied)
ACA Fid Light PSF	 Valid Time range Images of fiducial lights PSFs [from calib]
ACA Read Noise Calibration Table	*For each temperature step* Temperature Read Noise in each quadrant
ACA Color Magnitude Correction Table	*For each calibrated color value* Color Color magnitude correction
Gyro Data	*For every set of gyro values* (Gyro-only aspect solution) Start time, stop time Gyro count data (4)

Table 5.4-7: Level 1 Standard Data Products (continued)

Data Product	Data Items
	Gyro interpolation flag (4) Gyro rate data (4) Gyro axis rotation data (4) Uncorrected S/C gyro rate Corrected S/C gyro rate *Header data:* Fit parameters Noise thresholds
Gyro Calibration Data	*For each gyro* Start time, stop time Gyro ID Alignment Scale factor Nominal Bias rate Gyro noise level *Header data:* Gyro to SC transform matrix
Gyro Status History	*For each change of gyro used* Start and Stop Time Active gyro IDs
Gyro Rotation Angles	*For each entry in the Gyro Data product* Time Scale factors Bias rates S/C rotation angles
Fid Light Calibration	*For each fid light* Fid light number Fid light location in STT coords Nominal brightness
ACA Sightings	*For each ACA readout* Time *For each image: (star or fid)* Image centroid (pixels) Image centroid (angle) Image brightness Image status (detected or not) Image fitted background Image fitted χ^2 *for each guide star image only:* Image color flag Image spoiler flag
ACA Kalman Data	*For each ACA readout* Time Forward filter outputs

Table 5.4-7: Level 1 Standard Data Products (continued)

Data Product	Data Items
	(Kalman corrected centroids) Reversed data SC attitude estimate Gyro drift estimate Kalman covariance Attitude update quaternion
ACA Photo Centroids	*For each photo interval* Time (photo reference time) Reference time Centroids (stars and fids) at reference time Star centroids motion Fid light centroids motion Fluxes at reference time
Image Motion Correction	*For each (SAP) time of motion interval* Time Star field motion Fid light field motion Relative field motions (stars to fids) Corrected centroid positions
Reference Aspect Solution	*For each observation segment* *Used to anchor final aspect solution* Anchor Time Aspect solution at ACA Aspect solution at SIM Fid light solution
Calibration Data	
Vignetting Map	*One map for each mirror shell, and for the sum of shells. In each map, one set of the following values for each step in Energy, off axis angle and azimuth. Step sizes are to be determined after calibration.* Energy Off axis angle Azimuth angle Vignetting factor
Ancillary Response File	*Definition in Legacy No. 2* Energy response information
Redistribution matrix file	*Definition in Legacy No. 2* Energy resolution matrix (one per ACIS quadrant)
QE Uniformity Map	*Array* Relative detector QE sensitivity versus position
PSF Models	*Point Spread Functions for different detector positions as a function of energy*

Table 5.4-7: Level 1 Standard Data Products (continued)

Data Product	Data Items
	Response as a function of detector position and energy, either in image format or as analytic model
PSF Size Table PSF Gaussian Width versus off axis angle, azimuth and energy	
Background Model	*Model parameters for predicted background, calculated for considered observation* Composite background model solar galactic extragalactic particle internal
X-ray Level 1 Basic Data Products	
Level 1 Photon List	*For each event; includes bad events* X, Y sky pixel coordinates Tangent plane pixel Detector pixels Chip Detector pixels for given chip Chip id PHA, PI raw and corrected pulse height Photon arrival time Time on UTC scale at spacecraft Time on TT scale at barycenter for photon Rise time, spread, grade Status code (good event) *For the photon list as a whole:* Good Time Intervals, Data Subspace Information, World Coordinate Systems
Sky Image	*One for each PI band: event counts vs sky pixel*
Detector Image	*One for each PI band: event counts vs detector pixel*
Exposure Map	(Raw Exposure Map Array) *Image of livetime versus sky pixel corrected for obscuration using aspect solution*
Effective Exposure Map	*One for each PI band: Image of exposure time vs sky pixel, corrected for: instrument quantum efficiency, filter/window transmission and vignetting.*
Effective Area Map	*One for each PI band: Image of effective area vs sky pixel, corrected for: instrument quantum efficiency, filter/window transmission and vignetting.*

Table 5.4-7: Level 1 Standard Data Products (continued)

Data Product	Data Items
Predicted Background Map	*Array of Expected background counts versus detector pixel*

1.1.1.3 Level 2 Processing Overview Level 2 Products (Table 5.4-8) are typically results generated for each source and, if applicable, spectrum detected from an observation. AXAF users would look at these results to gain a first impression as to the observation's scientific content and could do fairly detailed analysis for uncomplicated sources and source regions using these products. Level 2 Products include the photon events determined, through source detection, to correspond to the source (zero-order spectrum for grating observations), dispersed spectrum (grating observations), the local background, and to a standard background. Source properties such as position, count rate, and period are derived directly from observation and calibration data. Fluxes are derived using additional assumptions about the source. Standard timing analysis results are supplied for each source (zero-order spectrum), its local background, and for the standard background.

Level 2 Products include standard spectra and spectral analysis results. Low-resolution spectra, based on the intrinsic pulse-height resolution of the FPSI, are supplied for all sources (zero-order spectra) and backgrounds. High-resolution spectra are standard spectral analysis results are provided for grating observations. Level 2 Products include non-AXAF information applicable to each source (e.g. potential multiwavelength identifications and likely source type based on f_X/f_{other} ratios) or high-resolution spectrum (line/edge identifications).

Table 5.4-8: Level 2 Standard Data Products

Data Product	Data Items
X-ray Level 2 Basic Data Products	
Level 2 Photon List	*Photon list updated with results of level 2 processing and screened to include 'good' photons only.* *For each event*
(the Photon List files listed below contain some subset of the information noted here)	X, Y sky pixel coordinate
	Tangent plane pixel coordinate
	Tiled detector pixel coordinate

Table 5.4-8: Level 2 Standard Data Products (continued)

Data Product	Data Items
	Chip Detector pixel coordinate Chip id PHA, PI raw and corrected pulse height Photon arrival time Time on UTC scale at spacecraft Time on TT scale at barycenter Rise time, spread, grade Status code (good event) Source number Grating order (for grating data) Photon energy (for grating data) Dispersed grating coordinates (for grating data) *For the photon list as a whole:* Good Time Intervals, Data Subspace Information, World Coordinate Systems
Background Map	*One for each Level 1 Image.* Background counts in Image bins, after extracting sources.
Source List	*For each source* Source number Source candidate ID Detection method Significance (in sigma) Probability Dispersed spectrum number J2000 position, error Sky pixel position Broad band count rate Broad band flux
Source detection processing summary	*For each band* Band name Band channel max, min Threshhold Background rate
Source Analysis Products	

Table 5.4-8: Level 2 Standard Data Products (continued)

Data Product	Data Items
Source Photon Filter	*Defines a subset of Level 2 Photon List, containing photons from the source region - 1 per source*
Local Background Photon Filter	*Defines subset of Level 2 Photon List, containing photons from the local background region - 1 per source*
Background Photon Filter	*Defines subset of Level 2 Photon List, containing photons used in the analysis of the field background properties*
Source Properties	*1 for each source* Source properties keywords: Source number in this observation Source Name Alternate source identifications (HEASARC CATIDn) Extended flag Extent size Variability flag Number of instrumental colors PHA range for colors Colors Pulse pileup fraction (ACIS only) Source detection or background determination method Non-AXAF data: Redshift, velocity, spectral type, Object class Source Non-AXAF identification Counts per order (Grating data only) Integrated fluxes per order (Grating data only) Total integrated flux (Grating data only)
Source Map	Image of region around source *omitted for background files*

Table 5.4-8: Level 2 Standard Data Products (continued)

Data Product	Data Items
	(This product may be embedded in the Source List.)
Source Flux Table	*1 record for each PI band* Band min and max Count rate and errors Flux and errors
Source Cross-ID Table	*Non-AXAF data; For each reference* NED and SIMBAD references
Light Curve Table	*1 per source* *For each light curve bin* SCC time TT barycentered time Fluxes in each band in time bin Error on fluxes Pulse pileup fraction (ACIS only)
Light Curve Power Spectrum	*Power spectrum array of light curve*
Field Background Light Curve	Light curve table (as Source Light Curve)
Local Background Light Curve	*1 per source* Light curve table (as Source Light Curve)
Source PHA Spectrum	PHA file for source pulse height spectrum (1 per source) *Format to support compatibility with XSPEC and standard OGIP spectral file.* *For each channel* Channel Counts Rate Errors *Include pulse pileup header keyword for ACIS*
Background PHA Spectrum	PHA file for field background Data as for Source PHA spectrum
Local Background PHA file	PHA file for local background (1 per source)

Table 5.4-8: Level 2 Standard Data Products (continued)

Data Product	Data Items
	Data as for Source PHA spectrum
Source RMF calibration file	Mean spectral response matrix calibration for source region
Source ARF calibration file	Mean spectral efficiency calibration for source region
Grating Data Products	
Zero Order Image	*(Grating only)* Image array of zero order photons only, with aspect applied
TG Vignetting Map	HRMA vignetting vs wavelength, shell, and source pos Averaged over aspect history
Spectrum	*High Resolution Calibrated Spectrum* Spectrum coordinate system Spectrum array (calibrated counts and flux versus energy). Spectrum extraction masks. This product is only generated for grating data.
Spectrum Background	*Local background for dispersed Spectrum* Spectrum coordinate system Spectrum array (counts, flux) Spectrum background masks
Spectrum RMF	Mean spectral response matrix calibration for source region; position and blur vs wavelength
Spectrum ARF	Mean spectral efficiency calibration for source region; grating, mirror, detector. Average for extraction region.
Spectrum Background ARF	Mean spectral efficiency calibration for background region; grating, mirror, detector. Average for extraction region.
Spectral Exposure Map	

Table 5.4-8: Level 2 Standard Data Products (continued)

Data Product	Data Items
	Exposure time vs. dispersion coordinate
Spectral effective exposure map	Exposure time vs. dispersion coordinate corrected for detector QE, vignetting, gaps
Spectral Effective Area Map	Effective area vs dispersion coordinate, corrected for detector QE, vignetting, gaps
Spectrum Background Exposure Map	Exposure time vs. dispersion coordinate
Spectrum Background effective exposure map	Exposure time vs. dispersion coordinate corrected for detector QE, vignetting, gaps
Spectrum Background Effective Area Map	Effective area vs dispersion coordinate, corrected for detector QE, vignetting, gaps
Spectral Line Feature Table	*Spectral features - only present for grating data* *For each line or edge identified* Continuum counts, flux Line counts, flux Wavelength/energy Edge strength Line equivalent width, fwhm
ACIS Products (for each source)	
Grade Fractions	*For each split event grade* Grade Fraction of events in grade
Processing Information	
Observation Index	*For each data product* Data product type Number within type Filename
SDP Profile	ASCII SDP Profile file
SDP Log	ASCII log file

Table 5.4-8: Level 2 Standard Data Products (continued)

Data Product	Data Items

1.1.1.4 Level 3 Processing Overview

Level 3 Products (Table 5.4-9) are catalog summary products and the results of aggregate analysis. AXAF users would begin browsing the AXAF data holdings at this level to find answers to questions such as "was this particular source observed by AXAF?" or "how many pulsars has AXAF looked at?". The answers guide the users in the retrieval, if desired, of the relevant Level 2 Products for further analysis and/or Level 1 Products for in-depth analysis. Also see Search and Retrieval, section **??**.

Level 3 products are created only from non-proprietary data. Certain Level 3 Products are updated automatically as observation data becomes public, specifically the AXAF Observation, Image, Source, and Spectrum Lists. Update of the Bibliographic, Object, and Identification and Cross-Reference Catalogs is performed, at ASC staff request, when publications based on data obtained with AXAF become available. Other Level 3 Products are created upon ASC staff request either when a sufficient amount of data on interesting objects is accumulated or otherwise as specified by AXAF science policies. Update of *all* Level 3 Products is initiated only through ASC staff request.

Table 5.4-9: Level 3 Standard Data Products

Data Product	Data Items
Global Catalogs - to be maintained up to date	
AXAF Observation List	*List of all observations made with all instruments. All entries are derived from Observation Summary products.* Observation ID Processing System Version (most recent processing) SDP Profile (most recent processing) Processing Number (most recent processing) Detector ID Grating Detector Mode Focus SIM Position Next-In-Line Detector NIL Detector Mode Observation ID

Table 5.4-9: Level 3 Standard Data Products (continued)

Data Product	Data Items
	Target Name Target Coordinates Start and stop date/time Principal Investigator Proposal Title Requested Time Number of detected sources Number of good events Ontime Livetime Public Date *Note: These quantities are distinct from those in the OCAT, in that they represent the post-observation actual values derived from the processing of the data and reflecting unplanned on-board events and commanding, rather than the pre-observation intended (planned) values.*
AXAF Pointing Catalog	*List of all pointings made by AXAF. An observation is made up of several pointings. This list is needed to determine precise sky coverage. Derived from Observation Table products.* Observation interval name observation ID Observation interval number within observation Start and stop time Detector ID Pointing direction roll angle livetime
AXAF Candidate Source Catalog	*Summarized information on all sources found by standard data processing. Provides summary of source properties derived in Level 2 Processing. Does not identify multiple observations of the same source.* Candidate source ID observation ID(s) extended source flag, extent size variability flag, range; period flag, number of periods, period values For each PI band: count rates, fluxes, colors significance Low resolution spectral fit info Public date

Table 5.4-9: Level 3 Standard Data Products (continued)

Data Product	Data Items
AXAF Source Catalog	*Summarized information on all sources detected by AXAF above a fixed (3.5 sigma TBR) significance level. Provides summary of source properties. Identifies multiple observations of the same source and assigns unique designations to sources.* source ID candidate source ID(s) observation ID(s) source name source class extended source flag, extent size revised variability/period info: flags, variability range, number of periods, period values for each PI band: mean count rates, fluxes, colors spectral fit info for low resolution spectra (parameter vector values) Public date (of most recent observation)
AXAF Spectral Catalog	*Summarized information on all high resolution spectra produced by AXAF.* candidate source ID source ID source name observation ID detector configuration continuum fit observed lines/edges IDs line/edge strengths other TBD Public date
Source Bibliographic Catalog	*Primary goal of this catalog is to provide references to published literature for user specified AXAF sources/source classes/keywords. At a minimum catalog includes:* source ID source class (same as in Object Catalog, see Level 3 Processing Overview) bibliographic ID bibliographic reference keywords abstract other TBD
AXAF Bibliography	*Complete list of AXAF related publications. Includes papers on calibration and instrumentation as well as observations.*

Table 5.4-9: Level 3 Standard Data Products (continued)

Data Product	Data Items
	Bibliography ID bibliographic reference title keywords abstract
AXAF Identifications and Cross-Reference Catalog (AICRC)	*For sources from other catalogs, it lists their X-ray properties as observed by AXAF.* non-AXAF source ID AXAF observation ID(s) detector configuration AXAF detection flag AXAF source ID AXAF flux/upper limit information from astronomical databases (e.g. NED, Simbad) other TBD
List of Classes	*List of the types of source class (quasar, white dwarf, etc.) used in the database. Identifies the subset of classes for which Class Catalogs are maintained.* Source class code Source class name Class Catalog name (or blank)
Class Catalog	*Catalog of AXAF sources by type of object. Subset of Source Catalog.*
	Other Data Products
AXAF Images In Region	*List of all images produced by AXAF in a given sky region (or including a given position). It primarily serves as a quick reference for identifying images containing user specified region of the sky.* Product filename observation ID detector ID image center position and roll angle image region description livetime Observation date start/stop Public date
Selected Region List	*List of particularly interesting areas on the sky (e.g. M31, Orion, Galactic Center, Virgo, etc.)* Name of region Region ID (filename to use)

Table 5.4-9: Level 3 Standard Data Products (continued)

Data Product	Data Items
	Region specification file
Selected Region File	*Standard region data product for each selected region* REGION table: set of region specifier strings
Slew Photon Lists	*These are standard photon list files, see Level 1 products*
Level 3 Map products	
Selected Region Mosaics	mosaics of AXAF observations covering regions in Selected Region List
Diffuse Background Maps	maps of background, background spectra, etc.
Diffuse Background Model	all-sky maps of components of diffuse background model
Sky Coverage Map	*Map of region of sky covered by AXAF observations. Generated from Pointing Catalog or OCAT.*
Ancillary Databases	
Ephemeris	*For every 10 min of mission* Time Solar position vector Lunar position vector AXAF position vector McIlwain parameters OCC time delay AXAF long, lat, height
Solar System Ephemeris	*For each day* Time Daily Solar position vector Daily Jovian position vector Daily Saturnian position vector
Housekeeping Database	*For every TBD* Time SI at focus SI next-in-line SI temperature step SI pressure step SI high voltage Grating in path Instrument mode
Event Rate Database	*For every 10s (TBR)* time

Table 5.4-9: Level 3 Standard Data Products (continued)

Data Product	Data Items
	background rates total event rates other rates TBD
Aspect Solution Database	*For each ACA Photo* Time Aspect Solution (RA, Dec, Roll, Offsets)
Screening Database	*For each Temporal Status Interval* Time SI at focus SI NIL Temperature code Pressure code HV step Grating Data mode Viewing geometry Radiation flag Aspect quality flag Telemetry problem flag

1.1.1.5 Special/Calibration Processing Overview Any observer-requested special processing for a science observation is performed subsequent to the standard processing as a separate SDP job under the control of a Special Processing Profile supplied by the observer (with the proposal or via other TBD interface with the ASCDS). Any Special Products are then produced and archived in addition to the Standard Products. The format of the Special Profile is no different than the Standard, but in this case sets up a processing configuration and provides the necessary models and parameters required to produce the special products desired. Any Standard Products which are unchanged and can be utilized during the special processing are not recreated. The ASC staff (and the user TBD) can view and modify the Special Profile associated with the observation prior to processing execution. Processing of calibration observations is handled as a variant to this same mechanism, where each calibration observation is linked to a (possibly unique) Calibration Processing Profile as determined by the ASC staff. A Calibration Profile allows the option to first perform processing according to the Standard Profile, to a designated depth, and then the processing according to the Calibration Profile itself. The ASC staff can copy, input, modify, or delete Special and Calibration Profiles, as well as associate them to observations.

1.1.1.6 Reprocessing Overview Reprocessing is performed identically to the standard processing of original data except that the products are intended to replace, as opposed to add to, existing archived products. Reprocessing is always initiated by the ASC staff. The reason for reprocessing might be improved calibrations, an improved aspect solution, or an improved/additional processing algorithm (*e.g.* source detection). A Processing Profile distinct from the Standard is provided by the ASC staff with the reprocessing request. Reprocessing can be requested for an observation part, a full observation, a few observations, or days, weeks, months, or even years of accumulated observations. The ASC staff can select the observations to be reprocessed according to list or time interval criteria, or criteria which can be translated to time intervals. Reprocessing can be requested to replace a single product, an entire Level, or multiple Levels of existing products. Reprocessing can therefore be requested to start from and stop at any point within the Level 0 through Level 3 sequence. Reprocessing from raw telemetry through Level 0 is specified in section **??**. Reprocessing from Level 0 through Level 1 is expected to be performed several times during the course of the mission to reflect improved understanding of the performance of AXAF. As with Special Processing, any existing products which are not to be modified are utilized by the reprocessing as necessary, but not recreated. Data products made obsolete by reprocessing are retained in the archive for reference, subject to AXAF science policies. The changes implemented by the reprocessing and the reasons for them are recorded with the reprocessed products.

1.1.2 Standard Data Processing Functional Requirements

1. The ASCDS standard processing shall be performed using an automated, on-line processing system (1854 3.2.5[3]).

2. The ASCDS standard processing shall be performed on the same type of computer hardware and under the same operating system as the ASCDS Data Analysis capability (section **??**) (1854 3.4[3]).

3. The ASCDS shall apply the standard processing to all science observations (1854 3.2.5[1]). All observer-requested special processing is to be in addition to the standard processing.

4. The ASCDS standard processing shall be constituted of a sequence of the Data Analysis Tools as described in section **??** configured as designated by the Standard Processing Profile using the scripting mechanism described in section **??** (1854 3.4[3]).

5. The format for the Standard Data Products listed in Tables 5.4-7, 5.4-8, and 5.4-9 shall be consistent across all AXAF detector systems. This means that, at a minimum:

   (a) all Standard Data Products shall include a standard set of information about the observation, the Observation Information.

   (b) all sky coordinates shall be in the same system

   (c) all image/spectrum field origins shall be in the same location

   (d) all PHA channel numberings shall begin at 0

   (e) all energies corresponding to a PHA channel shall apply to the linear arithmetic midpoint of the channel

   (f) all AXAF sources shall be named using the IAU convention

(g) all live time, effective area, and background maps shall use the same grid as corresponding image

(h) others TBD

1.1.2.1 Processing Control

1. The ASCDS shall perform Level 1 processing, creating/updating the corresponding products, as intervals of Level 0 Telemetry become available.

2. When sufficient Level 0 Telemetry for an observation has been collected (with TBD of the observing time), the ASCDS shall initiate the final Level 1 and the Level 2 processing of that observation (1854 3.4[9]).

3. If sufficient Level 0 Telemetry has not been accumulated for an observation and more than 1 month (SAP) has elapsed since the reception of the earliest data, the ASCDS shall initiate standard processing of the completed pointings accumulated so far. For any given observation, this shall be performed no more often than once per SAP (same SAP as above). (1854 3.2[4]).

4. The ASCDS shall provide the capability for the ASC staff to initiate SDP for a designated observation, observation part (set of complete pointings) or set of observations (1854 3.2[5], 3.4[9]).

5. The ASCDS shall allow the ASC staff to view essential data about each SDP job, including its status (TBD) and linkage to the applicable Processing Profile.

6. The ASCDS shall provide the ASC staff with the capability to (re-)prioritize, suspend, restart, and cancel SDP jobs. Allowable restart points include the start of the processing sequence and others TBD.

7. The ASCDS shall provide error handling and, where possible, automatic recovery from processing faults. The types and severity classes of processing faults which determine subsequent recovery actions are TBD.

8. The ASCDS shall automatically suspend an SDP job that fails one of TBD in-line checks or has not completed within a Profile-specified interval.

9. Upon automatic suspension of any SDP job, the ASCDS shall provide an alert to the ASC staff with an indication of the reason.

10. The ASCDS shall configure the standard processing and use any necessary parameters and models only as directed by the Standard Processing Profile.

11. The ASCDS shall accept and document in the Processing Log (TBR) ASC staff input of and modifications to the standard (default) processing setup and any necessary models and parameters contained within (or indicated by) the Standard Processing Profile (1854 3.4[10]).

12. The ASCDS shall provide TBD processing summaries, processing start, stop, and elapsed times, and SDP job status (at a minimum pending, active, suspended) for display to the ASC staff.

13. The ASCDS shall log TBD processing summary data, SDP job status changes, fault indications, recovery actions (whether automatic or manual), and accounting data. This accounting data shall include, at a minimum, for each pointing (1854 3.2.6[1]):

    (a) Data time interval (UT)
    (b) Spacecraft ID
    (c) Observation ID
    (d) Pointing ID
    (e) SDP Job ID
    (f) Time of processing initiation
    (g) Time of processing completion
    (h) Software version(s) used
    (i) Location of products in archival storage
    (j) ID of the calibration models/parameters used
    (k) ID of the Processing Profile used
    (l) Description of SI configuration used
    (m) A TBD summary of processing results
    (n) Other TBD information necessary for accurate processing accounting

14. The ASCDS shall provide Processing Status (TBD) for each observation or observation part processed. This forms a component of the overall Observation Status which is maintained in the Observing Catalog (1854 3.1.6.1[10]).

15. The ASCDS shall generate an Observation Summary (Table **??**) as a Standard Product.

16. The ASCDS shall accept a unique Special Processing Profile for any science observation to accommodate those observers who wish to specify the type of non-standard (Special) processing to be performed on the gathered data (1854 3.2[8]).

17. The ASCDS shall accept a unique Calibration Processing Profile from the ASC staff for each calibration observation.

18. If a Special Profile is supplied by the observer as part of a science observation, the ASCDS shall first process to completion the gathered data according to the Standard Profile and then perform the special processing according to the Special Profile.

19. The ASCDS shall first process data gathered from calibration observations according to the Standard Profile, if so indicated in the Calibration Profile, to the depth specified in the Calibration Profile and then perform the processing indicated by the Calibration Profile.

20. The ASCDS shall provide the capability for the ASC staff (and the user TBD) to input, modify, copy, replace, and link Special Processing Profiles.

21. The ASCDS shall provide the capability for the ASC staff to input, modify, copy, replace, and link Calibration Processing Profiles.

22. The ASCDS shall lock out modifications or replacements to any Processing Profile while it is in use by any active SDP job.

23. The ASCDS shall provide the capability for the ASC staff to initiate reprocessing using a designated Reprocessing Profile for a designated observation span. An observation span can encompass a single observation, an observation part, a set of observations (possibly with multiple instruments), or the set of complete observations contained within a designated time interval (1854 3.2[7]). The observation span can be designated as a single observation or pointing, a list of observations or pointings, or as a time interval or list of time intervals encompassing a set(s) of observations or pointings.

24. The ASCDS shall provide the capability for the ASC staff to designate the scope of a reprocessing request. The scope can be designated as an individual Standard Product, a set of Standard Products, a Level of Standard Products, or a set of Product Levels (1854 3.2[7]).

25. Upon ASC staff request, the ASCDS shall replace the corresponding products in the archive with the reprocessed products. Obsolete versions of the products will be retained for reference.

26. The ASCDS shall automatically determine, from information supplied in the Standard Profile and that designated for special or reprocessing, which intermediate products do not have to be recreated in order to satisfy the special or reprocessing request.

1.1.2.2 Level 1 Processing

1. The ASCDS shall automatically configure the Level 1 processing sequence from the appropriate subsets and substitutions of the Data Analysis Tools (Appendix C) as designated in the Standard Processing Profile.

2. For each observation, the ASCDS shall produce and archive the Level 1 Products, suitable for further scientific analysis, that are specified in Table 5.4-7 (1854 3.2.5[4]).

3. If requested by a observer-supplied Special Profile, the ASCDS shall automatically configure an auxiliary Level 1 processing sequence from the appropriate subsets and substitutions of the Data Analysis Tools (Appendix C) as designated in the Special Profile to produce and archive the observer-requested Special Level 1 Products.

4. The ASCDS shall accept from the ASC staff a request to re-Level 1 process the Level 0 Products of a span of observations according to a staff-supplied Reprocessing Profile. The observation span can be designated as a single observation or pointing, a list of observations or pointings, or as a time interval or list of time intervals encompassing a set(s) of observations or pointings.

5. The ASCDS shall derive an ex post facto Aspect Solution for observations made with the AXAF-I observatory which utilizes data from the on-board star camera, fiducial lights, and inertial reference systems together with the AXAF Star Catalog (1854 3.2.3[2], 3.4.1[14]).

6. Any ASCDS-derived Aspect Solution shall include the estimated accuracy (uncertainty) of the solution at each aspect point.

7. The ASCDS-derived aspect solution algorithms shall provide for contingencies such as missed acquisition of an aspect star, loss of accurate star data when pointing near the sunlit earth, and others TBD (1854 3.2.3[3]) using the sun and earth sensors and other TBD subsystems.

8. For each observation, the ASCDS shall transform the telemetered FPSI readout, correcting for instrument response and aspect motion, to a complete set of photon events gathered over the the entire FPSI field-of-view during the entire observing interval (1854 3.2.4[2], 3.2.5[1],[2]). Events determined to be invalid shall be identified as such and included in this set.

9. The ASCDS shall produce and archive a Mission Timeline. The Mission Timeline is a time-aligned series over the mission lifetime of TBD ancillary, spacecraft, environmental, and on-board data and events which shall include, at a minimum, the following:

   - Spacecraft state vector
   - Spacecraft altitude
   - Spacecraft celestial pointing angle
   - Spacecraft pointing angle relative to the sun
   - Spacecraft pointing angle relative to the moon
   - Spacecraft pointing angle relative to the spacecraft velocity vector (*ram* vector)
   - Bright object detector readout
   - Background monitor readout
   - Sun sensor readout
   - Earth sensor readout
   - Spacecraft attitude
   - Spacecraft attitude rates
   - PCAD mode (slew, gyro-only fixed, star tracking. etc.)
   - Aspect Solution quality

10. The ASCDS shall provide a capability to filter photon events based on logical combinations of criteria which reference the Mission Timeline, the Aspect Solution, and others TBD. These Filtering Criteria are a component of the Processing Profile. Filtering for this purpose means annotation for possible elimination from downstream processing, not the elimination of any actual data (1854 3.2.4[1],[3]).

11. The ASCDS shall produce Images from photon events gathered during intervals which have been determined to be "good" per the Filtering Criteria defined in the Standard Profile (1854 3.2.4[3]).

12. The ASCDS shall archive Images and related data in FITS format (1854 3.2.8[4]).

13. The ASCDS shall, upon ASC staff request, recreate the designated Level 1 Products from the Level 0 Products of a designated span of observations according to a staff-supplied Reprocessing Profile. The observation span can be designated as a single observation or pointing, a list of observations or pointings, or as a time interval or list of time intervals encompassing a set(s) of observations or pointings.

1.1.2.3 Level 2 Processing

1. The ASCDS shall automatically configure the Level 2 processing sequence from the appropriate subsets and substitutions of the Data Analysis Tools (Appendix C) as designated in the Standard Processing Profile.

2. For each observation, the ASCDS shall produce and archive the Level 2 Products, suitable for further scientific analysis, that are specified in Table 5.4-8 in order to provide initial information as to scientific content and to guide further off-line analysis (1854 3.2.5[4],[5]).

3. If requested by an observer-supplied Special Profile, the ASCDS shall automatically configure an auxiliary Level 2 processing sequence from the appropriate subsets and substitutions of the Data Analysis Tools (Appendix C) as designated in the Special Profile to produce and archive the observer-requested Special Level 2 Products.

4. The ASCDS shall, upon request from the ASC staff or the active Reprocessing Profile, recreate the designated Level 2 Products from the designated Level 1 Products of a set of observations according to the staff-supplied or active Reprocessing Profile. The observation span can be designated as a single observation or pointing, a list of observations or pointings, a time interval or list of time intervals encompassing a set(s) of observations or pointings, an instrument or instrument mode, or as TBD.

1.1.2.4 Level 3 Processing

1. The ASCDS shall automatically update and rearchive the AXAF Observation, Image, Source, and Spectrum List Level 3 Products (Table 5.4-9) when the antecedent data products become public.

2. The ASCDS shall, upon ASC staff request, update and rearchive the requested Level 3 Products based on the accumulated Level 1 and/or Level 2 Products that have been created and have become public since the last update of each requested Level 3 Product (1854 3.3.2[6], 3.4.5[5]).

1.1.3 Standard Data Processing Performance Requirements

1. The ASCDS shall standard process one week's worth of observations in less than 40 hours (1854 3.2[6]).
2. The ASCDS shall send to the observer a copy of the standard processed data within 1 week of observation completion (1854 3.2[2]).
3. If an observation is not complete within one month and the observer so requests, the ASCDS shall provide the standard processed partial data set within 1 week of data receipt from the most recent complete pointing (1854 3.2[4]).
4. The ASCDS shall standard process a section of observation data (a set of complete pointings) within 24 hours of data receipt from the most recent complete pointing (1854 3.2[5]).
5. The quality of the ASCDS-derived aspect solution shall be such that, under normal conditions (TBR) and the assumptions of perfect HRMA and SI resolution, the reconstructed image of an X-ray point-like source has a spread diameter of less than 0.5 arcsec rms within the central 5 arcmin radius (1854 3.2.3[1]).
6. The accuracy of the ASCDS-derived aspect solution shall be such that, under normal conditions (TBR) and the assumptions of perfect HRMA and SI resolution, any pixel of the reconstructed image can be positioned on the sky to within 1.0 arcsec rms of the true position (1854 3.2.3[1]).