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EQUIPMENT SPECIFICATION FOR
ASPECT CAMERA ASSEMBLY
ADVANCED X-RAY ASTROPHYSICS FACILITY - IMAGING
Configuration Item No. L70701P

1.0 SCOPE

This document establishes the performance, design, development, and verification requirements of the Aspect Camera Assembly (ACA) for the Advanced X-ray Astrophysics Facility - Imaging (AXAF-I).

Throughout this specification the term "Section" refers to a part of this document and the term "Paragraph" refers to a part of a different document. A reference to any section or paragraph includes its subsections or subparagraphs. Acronyms are defined only at their first occurrences, but are summarized in Section 6.2.

2.0 APPLICABLE DOCUMENTS

The following documents and items of the exact issue and date form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced below and this specification, the requirements specified herein shall govern. Safety documents referenced in Section 3.3.6 shall be an exception and shall govern over this specification. TRW may consider contractor specifications or other documentation which satisfy the intent of the documents and items listed below as replacements of these documents and items.

2.1 MSFC Specifications

Specification	Title
MSFC-SPEC-250A 1 Oct 77	Protective Finishes for Space Vehicles Structures and Associated Flight Equipment, General Specification
MSFC-SPEC-494A 30 Apr 73	Installation of Harness Assembly (Electrical Wiring) Space Vehicle, General
MSFC-SPEC-522B 1 Mar 88	Design Criteria for Controlling Stress Corrosion Cracking
MSFC-SPEC-1238 1 Nov 86	Thermal Vacuum Bakeout Specification for Contamination Sensitive Hardware

2.2 NASA Standards

NASA Standard	Title
MSFC-STD-156(1) 15 Nov 63	Riveting and Fabrication Inspection, Standard for ASME Boiler Code
MSFC-STD-486A(2) 11 Dec 87	Torque Limits for Threaded Fasteners
MSFC-STD-557 21 Sep 82	Threaded Fasteners, 6 AL-4V Titanium Alloy, Usage Criteria for Spacecraft Applications
MSFC-STD-561 15 Sep 82	Threaded Fastener, Securing of Safety Critical Flight Hardware
MSFC-STD-1249 11 Sep 85	Nondestructive Evaluation Guidelines and Requirements for Fracture Control Programs

2.3 Military Standards

Military Standard	Title
MIL-B-7883B 20 Feb 68	Brazing of Steel, Copper, Copper Alloys, and Nickel Alloys
MIL-C-17E(1) 9 Oct 79	Cables, RF, Coaxial, Dual Coaxial, Twin Conductors, and Twin Lead
MIL-M-13508	Mirrors, Glass, Front Surface Aluminized, for Optical Elements
MIL-O-13830	Optical Components for Fire Control Instruments
MIL-STD-454K 14 Feb 85	General Requirements for Electronic Equipment
MIL-STD-975G 1 Oct 86	Standard Parts List for Flight and Mission Essential Ground Support Equipment
MIL-STD-45662A 1 Aug 88	Calibration System Requirements
MIL-W-22759D(1) 29 Jun 73	Wire, Electric, Fluoropolymer-Insulated, Copper or Copper Alloy
MIL-W-81381A 4 Jan 82	Wire, Electric, Polymide-Insulated, Copper or Copper Alloy

2.4 Other Government Publications

Publication	Title
FED-STD-209B(1) 24 Apr 73	Clean Room and Work Station Requirements, Controlled Environments
JSC-SN-C-0005A 1 Mar 74	NSTS Specification, Contamination Control Requirements for the Space Shuttle Program
JSC-SP-R-0022A 9 Sep 84	General Specification, Vacuum Stability Requirements of Polymeric Materials for Spacecraft Applications
MIL-HDBK-5E 1 Jan 87	Metallic Materials and Elements For Aerospace Vehicle Structures
MIL-HDBK-978 (NASA)	Parts Application Handbook (To be used as a reference only)
MM-8070.2H 30 Mar 87	Specification and Standards for Approved Baseline List
MSFC-HDBK-505A 1 Jan 81	Structural Strength Design and Verification Program Requirements

MSFC-HDBK-527F 30 Sep 88	Materials Selection List for Space Hardware Systems
MSFC-HDBK-1453 1 Oct 87	Fracture Control Program Requirements
MSFC-LTR-EH02 (89-0782) 17 Oct 89	Electrical Wire Insulation, Guidelines for AXAF and AFE projects.
NHB 5300.4(3A-1) 1 Dec 76	Requirements for Soldering Electrical Connections
NHB 5300.4(3G) 1 Apr 85	Requirements for Interconnecting Cables, Harnesses, and Wiring
NHB 5300.4(3H) 1 May 84	Requirements for Crimping and Wire Wrapping
NHB 5300.4(3I) 1 May 84	Requirements for Printed Wiring Boards
NHB 5300.4(3J) 1 Apr 85	Requirements for Conformal Coating and Stacking of Printed Wiring Boards and Electronic Assemblies
NHB 5300.4(3K) 1 Jan 86	Design Requirements for Rigid Printed Wiring Boards and Assemblies
NHB 8060.1B 1 Feb 82	Flammability, Odor, and Outgassing Requirements and Test Procedures for Materials in Environments that Support Combustion
NSTS-1700.7B 1 Jan 89	Safety Policy and Requirements for Payloads Using the the National Space Transportation System (STS)
NSTS-07700J, Vol. XIV, Att. 1 27 Jan 88	Space Shuttle System, Payload Accommodations (ICD 2-19001)
NSTS-18798A 1 Apr 89	Interpretations of STS Payload Safety Requirements

2.5 TRW Documents

Documents labeled "TRW SExx" are TRW responses to NASA data requirements and will be given a “D” number at a future time.

Document	Title
D17387 **D** **17 Jan 96**	AXAF-I Remote Command and Telemetry Unit (RCTU) User Interface Requirements
D17389 **D1** (TRW SE19) **7 Oct 96**	Electromagnetic Compatibility Control Plan

D17393 **A** (TRW SE28) **11 Jan 96**	AXAF-I Preliminary Contamination Control and Implementation Plan
D22088 B (TRW SE11i) 5 Jan 95	AXAF-I Dynamic Loads and Criteria
D22095 **B** (TRW SE33) **1 Aug 95**	Fracture Control Plans & Procedures - Volume II
D22723 25 Aug 94	Printed Wiring Board Design, Manufacture and Control Plan for AXAF-I
EQ29-0008 **C** **18 Jul 96**	ACAF-I Equipment Specification for Command and Data Management Equipment (CDME)
EV1-8 **A** (TRW SE29) **11 Jan 96**	AXAF-I Environment Document
IF1-29 **13 Sep 96** **CADM released**	Spacecraft to Telescope Interface Control Document
PAR700-272 B, **C1** 1 Mar 94	Subcontractor Product Assurance Requirements for AXAF-I
SDR SE19	Subcontractor Data Requirement for Electromagnetic Compatibility Control Plan
TRW SE18 Rev B 11 Oct 94	AXAF-I Design Reference Mission
Drawing 301160 **CADM released**	ICD - Telescope, AXAF-I
Drawing C 301172 **CADM released**	SCD - Aspect Camera, AXAF-I
Drawing C301173 **CADM released**	SCD - Stray Light Shade, AXAF-I
Drawing C301174 **CADM released**	SCD - Processing Electronics Assembly, AXAF-I
Drawing C301326 **CADM released**	SCD - Aspect Camera to PEA Harness (W66), AXAF-I

2.6 Other Items

Item	Title
USA_AURA_STSI_GSC1_1001, USA_AURA_STSI_GSC1_1002 1 Aug 92	The Guide Star Catalog, Version 1.1

3.0 REQUIREMENTS

3.1 Item Definition

The ACA consists of these assemblies:

a. The Aspect Camera (AC), includes an Optical Telescope Assembly (OTA), redundant focal plane assemblies (FPAs) and a flip mirror to use the redundant FPA. The FPA records up to 8 images. The FPA contains a charge coupled device (CCD) having 1024 rows of 1024 columns of pixels. The CCD is electrically partitioned into four square quadrants. **Columns of pixels are numbered from -512 to +511. Rows of pixels are also numbered from -512 to +511. The orientation of rows and colums is different for the AC engineering model than for the AC flight unit, and for the primary and redundant focal planes within either unit. See Figures 1b, c, d and e.** The OTA forms real star and fiducial light images at the CCD surface.

b. The Processing Electronics Assemblies (PEAs), interface the AC to the AXAF-I Electrical Power Subsystem (EPS), to two ports of a Remote Command and Telemetry Unit (RCTU), and to an Interface Unit (IU). The RCTU and IU are parts of the Communications, Command, and Data Management (CCDM) subsystem. The PEA executes the four basic flight functions - search, monitor, track and calibrate. It provides image centroids to the on-board computer (OBC) and image data to the CCDM downlink for post facto aspect determination by ground based computers. The PEA also executes extended command, a function used both in flight and on the ground.

c. The Stray Light Shade (SLS), which protects the AC from stray light.

d. Cables, which connect the PEAs to the AC.

The AXAF-I mission profile is described in TRW SE18. The primary objective of the ACA during the mission phase is to measure the image positions of selected target stars and fiducial lights in its field-of-view (FOV). The AXAF-I OBC will use the image centroids provided by the ACA for real-time pointing. The ground based AXAF Science Center (ASC) will use the image distributions and inertial reference unit (IRU) and star catalog data for post facto aspect determination.

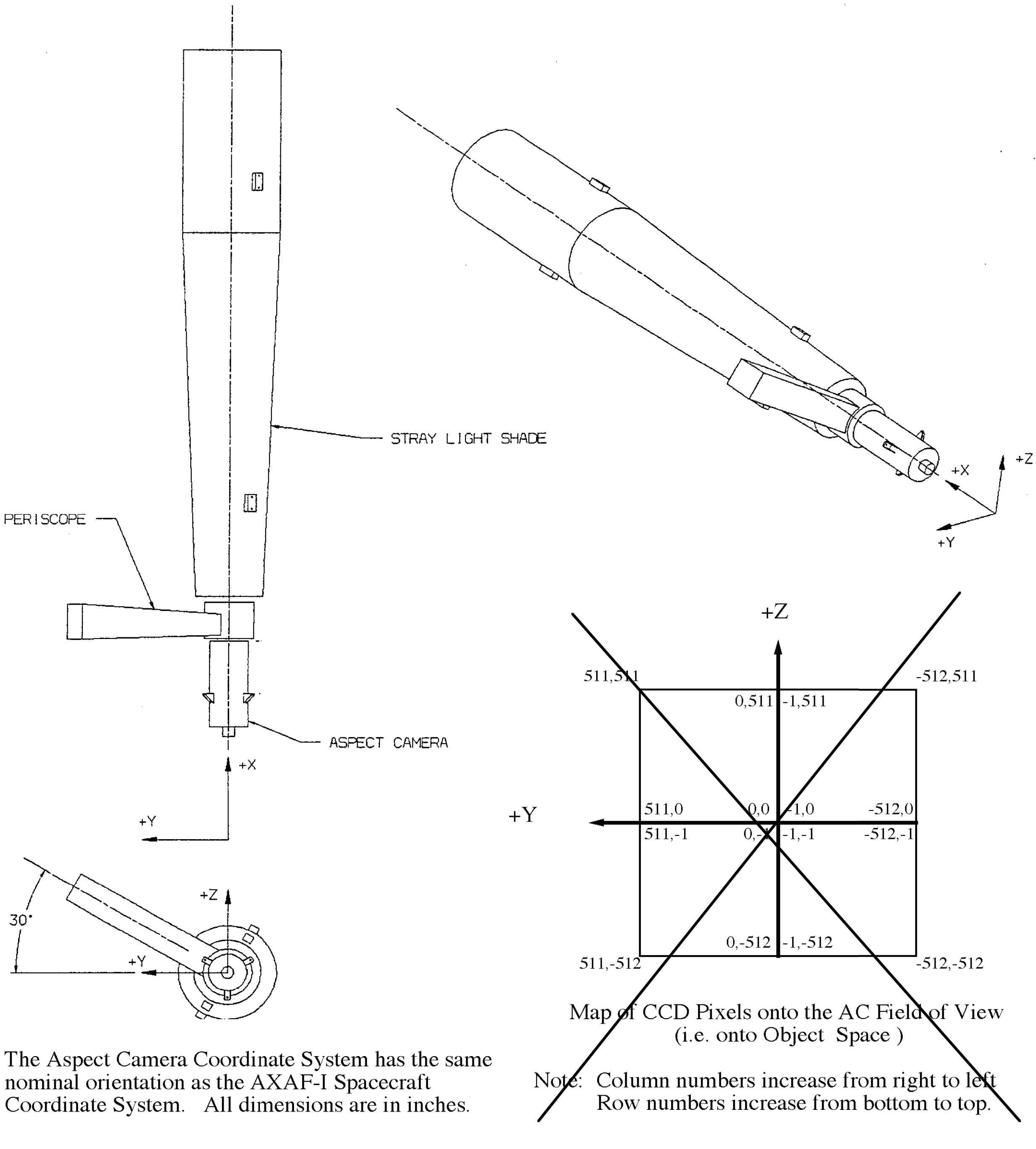
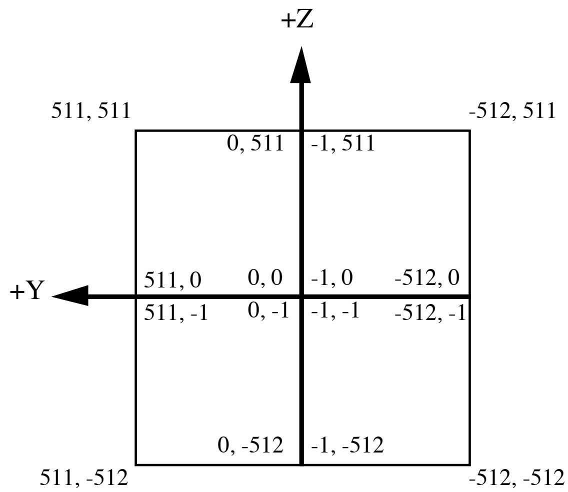
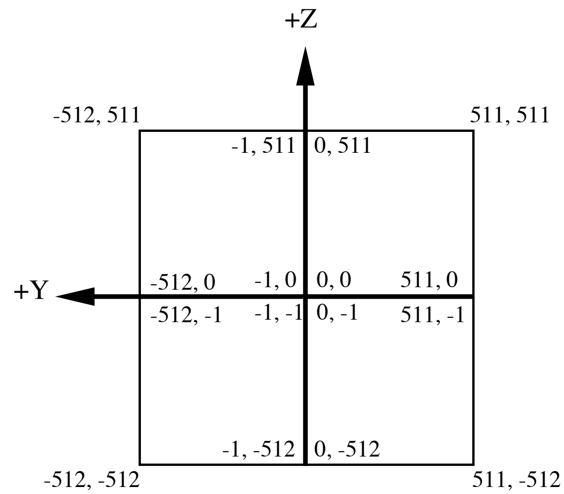


Figure 1**a**. ACA Coordinate System



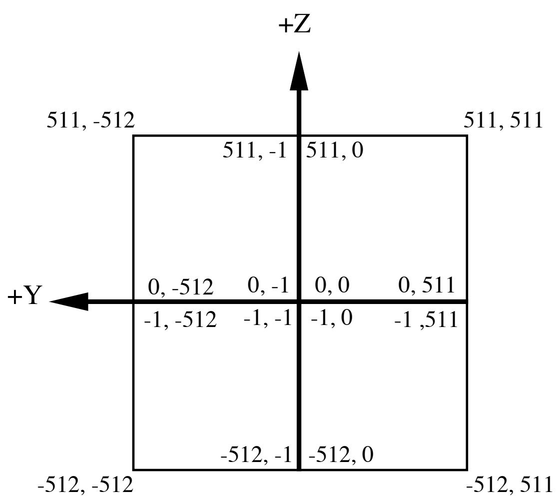
Note: Column numbers increase from right to left
Row numbers increase from bottom to top.

Figure 1b. Engineering Model, Primary CCD



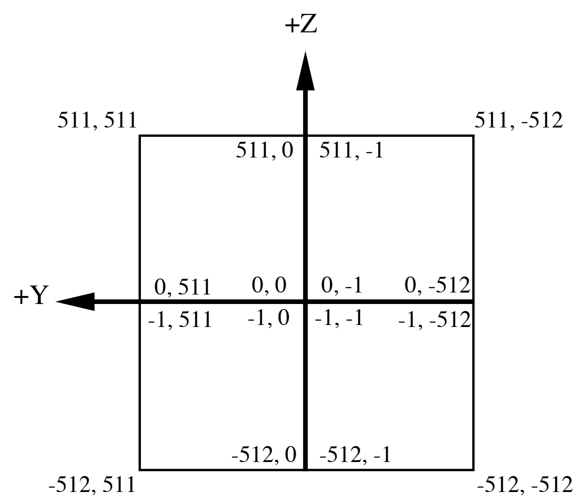
Note: Column numbers increase from left to right
Row numbers increase from bottom to top.

Figure 1c. Engineering Model, Redundant CCD



Note: Column numbers increase from bottom to top
Row numbers increase from left to right.

Figure 1d. Flight Model, Primary CCD



Note: Column numbers increase from bottom to top
Row numbers increase from right to left.

Figure 1e. Flight Model, Redundant CCD

Note: Each of these figures is a map of CCD pixels onto the AC field of view, (i.e., onto object space).

The ACA will simultaneously view multiple star images and accurately track their positions during an observation. Star centroids are used by the Pointing Control and Aspect Determination (PCAD) onboard attitude reference system which is used for real time pointing of the x-ray telescope line-of-sight (LOS) at an x-ray source within the errors and to the stability specified herein.

Post facto aspect determination is required for x-ray observations lasting longer than 100 continuous seconds. Aspect determination locates x-ray event positions with respect to known star positions as follows. The ACA provides relative positions of known observed stars and fiducial lights through its pixel image data. These data are later smoothed by IRU data. Science Instruments (SI) locate x-ray event positions relative to fiducial lights. The x-ray event positions are then located relative to the known stars by using the fiducial light data common to both scenes.

The AXAF-I orbit will be elliptical from 10,000 KM to 140,000 KM altitude, 28.5 degrees inclination.

3.1.1 Item Diagrams

The ACA is located on the High Resolution Mirror Assembly (HRMA) and functions as part of the PCAD subsystem. The ACA consists of an AC, two PEAs, a SLS, and interconnecting cables. Figure 2 shows the major ACA components. The AC contains an OTA and two FPAs. Figure 3 illustrates the Aspect Determination System concept.

Figure 4 shows the relationship between the ACA and HRMA components, including the Fiducial Transfer Mirror (FTM) close-out structure, which mounts to the aft end of the SLS. The FTM is a partial-aperture turning mirror which projects fiducial light images into the AC. The FTM is the last optical component of the Fiducial Transfer Periscope (FTP).

Star light will enter the OTA after passing through the SLS. Fiducial light beams travel through the FTP, reflect off the FTM and then enter the OTA.

The AC and SLS are mounted to brackets which extend from the HRMA. Light seals, installed at the HRMA assembly level, close out the gap between the FTM close-out structure and the AC. The PEAs are located on the optical bench assembly (OBA), which is a part of the telescope system (TS). Two electrical cables interconnect the AC and the two PEAs.

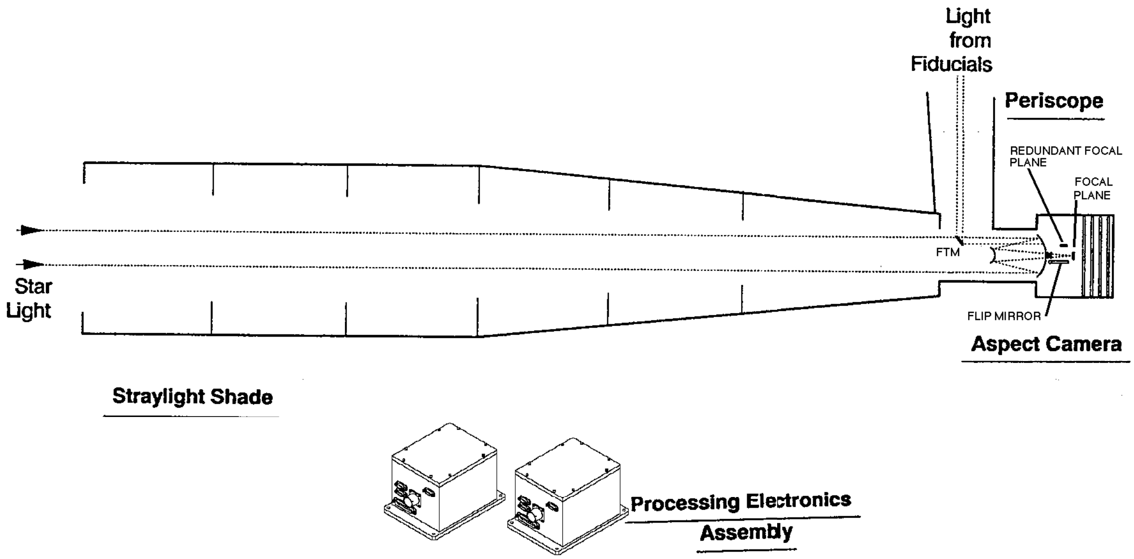


Figure 2. Aspect Camera Assembly Equipment Identification

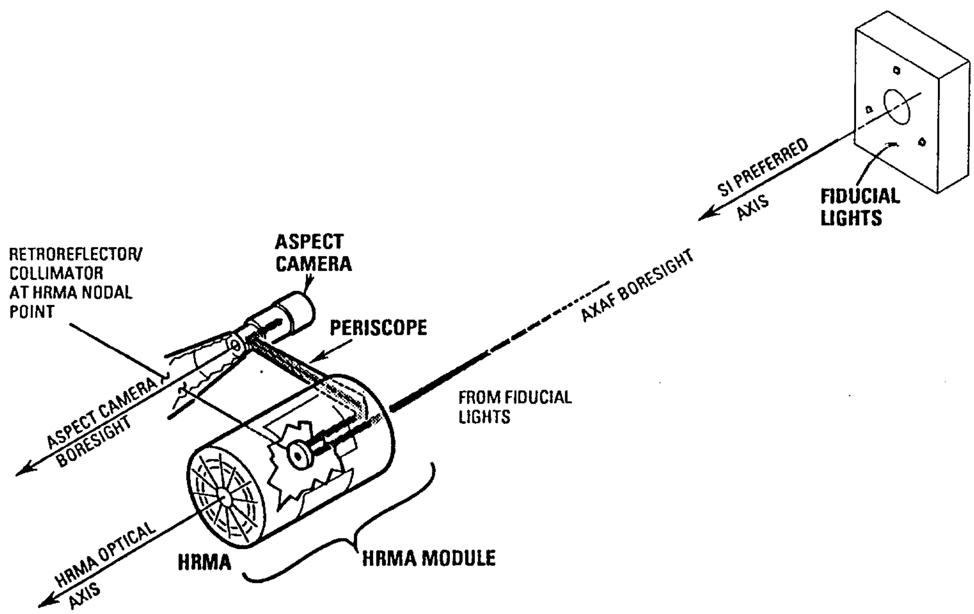


Figure 3. Aspect Determination System - Concept Layout

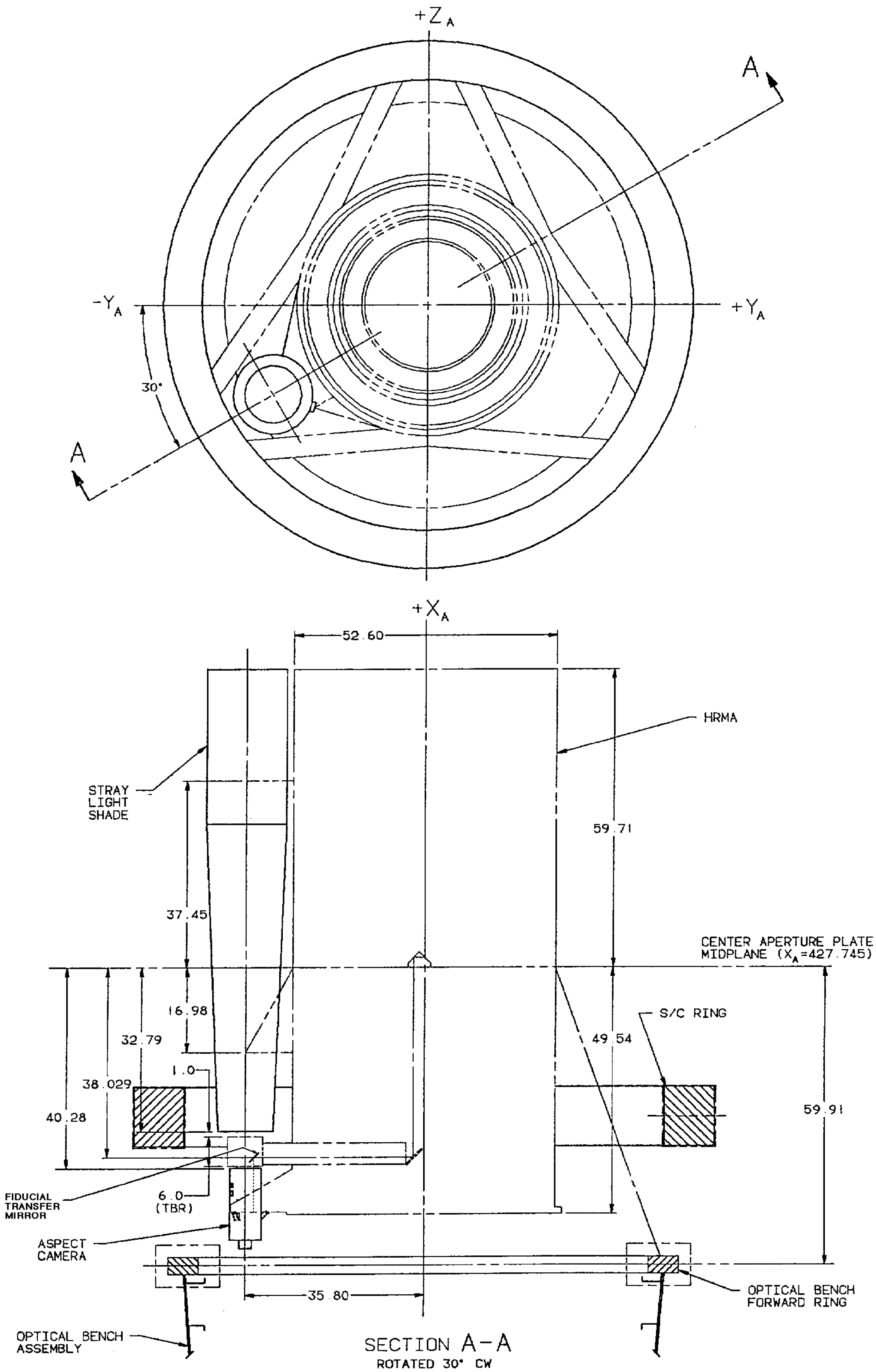


Figure 4. Aspect Determination Detail. All dimensions are in inches and are approximate. (For reference only.)

Figure 1 defines the ACA coordinate system and TRW Drawing 301160 references it to the spacecraft coordinate system. The origin of the FOV is the intersection of the four quadrants of the CCD as shown in Figure 1. Figure 1 also defines focal plane row and column numbers.

3.1.2 Interface Definitions

The statements in this section are requirements on AXAF-I entities other than the ACA subcontractor and can be relied on by the ACA subcontactor as the ACA design progresses and as implementation details are selected.

3.1.2.1 OBC Software Interface

3.1.2.1.1 **Constraint on Search Commands**

It will be ensured that any search command image location (see Section 3.2.1.11.1.3) will be separated by at least 65 arc seconds from all other tracked or monitored image locations. If this constraint is violated ACA accuracy cannot be assured.

3.1.2.1.2 (Reserved)

3.1.2.1.3 Functional Inputs

It will be ensured that the inputs listed in Section 3.2.1.10, Table II which allow the ACA to perform the functions of Search, Monitor, Track, Calibrate and Extended Command will be supplied. Violations will be indicated as a syntax error (see Section 3.2.1.15.6).

3.1.2.1.4 Constraints on On-Orbit Calibration

3.1.2.1.4.1 Responsivity Calibration Constraints

During responsivity calibration it will be ensured that the FOV will contain no star brighter than instrument magnitude 6 and the nominal commanded integration time will be chosen so that pixels[1] shall accumulate 70% to 80% of full well capacity at beginning of life.

3.1.2.1.4.2 Dark Current Calibration Constraints

[1] Exclusive of anomolous pixels (i.e. pixels with no output or abnormally high dark current).

For dark current calibration the commanded integration time will be 20 to 80 sec. If 20 sec is chosen, then the FOV will contain no star brighter than instrument magnitude 8.5, but if 80 sec is chosen then the FOV will contain no star brighter than instrument magnitude 10.0. Violation of any of these star magnitude constraints may result in local saturation of the CCD around the image of the bright star(s) during the calibration.

3.1.2.1.4.3 Calibration Telemetry Rate

During calibration it will be ensured that the spacecraft telemetry rate is set at 512 kbps, resulting in an IU data rate at the ACA interface of 593,920 bps. Use of any other telemetry rate will result in the loss of calibration data.

3.1.2.1.4.4 Calibration Command Sequence and Timing

It shall be ensured that the sequence delineated below will be followed when conducting an ACA calibration:

1. **A real-time command will be issued to the IU to begin calibration,**

2. **A real-time command to the ACA will be issued to begin calibration (see Section 3.2.1.11.1.5) with the constraint that the command to the ACA should be received no earlier than the command to the IU,**

3. **Sufficient time will be allowed for all of the commanded calibration data to be clocked out by the IU. Denote this time period as T_{wait}, with units of seconds·**

   $$T_{wait} = T_{int} + 5.0 = 0.020 * N,$$

   where T_{wait} **= waiting time,**
   T_{int} **= integration time and**
   N = the number of CCD rows to be read out

4. **Following a delay of at least T_{wait}, a real-time command will be issued to the ACA to stop calibration (see Section 3.2.1.16.1),**

5. **A real-time command will be issued to the IU to stop clocking calibration data with the constraint that sufficient time will be allowed so that there is at least a 2**

second delay between when the ACA receives the command to stop calibration and the IU receives the command to stop clocking.

3.1.2.1.5 Data Requests

During each 1.025-second period, the OBC will issue data requests sufficient to exhaust the data listed in Section~~s~~ 3.2.1.15.11 to the first of two ACA-dedicated RCTU ports. During each 1.025 second period telemetry will issue data requests sufficient to exhaust the data listed in Section 3.2.1.15.12 to the second ACA-dedicated RCTU port. If either of these constraints is not met the data that has not been requested will be lost.

3.1.2.1.6 Science Header Pulses

RCTU science header pulses will be provided every 2.050 seconds (nominal). See D17387, Paragraph 4.2.

3.1.2.1.7 Command Timing

There will be a time gap of at least two science header pulse periods (nominally 4.100 seconds) between the end of one group of command words (see Section 3.2.1.11.1.1) and the start of the next group. There will never be a time gap of more than one half of a science header pulse period between any two commanded words within the same group.

3.1.2.1.8 Command Count

The count field in the first word of each group of command words (described in Section 3.2.1.11.1.1) will contain the number of 16-bit words in the group that follow the first word. The count cannot exceed 63 since the field is 6 bits wide.

3.1.2.1.9 Command Checksum

The checksum field in the first word of each group of command words, described in Section 3.2.1.11.1.1, will be computed so that the least significant eight bits of the sum of all 8-bit bytes in the group, including the checksum and count, is zero.

3.1.2.1.10 Multiple Word Commands

Any multiple word command defined in Subsections of 3.2.1.11 will always be completely contained within one of the command word groups described in Section 3.2.1.11.1.1.

3.1.2.2 Ground Operations Interface

3.1.2.2.1 Dark Current Calibration Integration Time

Ground Operations will ensure that during dark current calibration the commanded integration time will cause pixel dark charge to accumulate to a nominal value of 10% of full well capacity when no image is on the pixel.

3.1.2.2.2 Line-of-Sight to the Sun

During normal operation the AC LOS will be maintained at least 45 deg from the sun line.

3.1.2.2.3 Fiducial Light Commanded Intensity

The fiducial light intensity will be controlled to ensure that each fiducial light image on the ACA focal plane will generate a minimum of 80,000 electrons at the end of an integration period.

3.1.2.2.4 Upload/Download Starting Address

The starting address for a memory upload or download must be an even number. See Sections 3.2.1.11.1.6.4 and 3.2.1.11.1.8.2.

3.1.2.3 Thermal Interface

The ACA design can rely on the thermal interface details defined in Paragraph 3.2.2.3.3 of IF1-29.

3.1.2.4 PCAD Interface

3.1.2.4.1 Absolute Pointing

The PCAD subsystem will maintain the AXAF-I boresight within a 30 arcsec radius of the x-ray source during 99% of the viewing time within an observation period.

3.1.2.4.2 Pointing Stability

The PCAD subsystem will maintain the AXAF-I boresight, with respect to the commanded direction, to within a 0.25 arcsec rms half-cone angle over 95% of all 10-second periods comprising an observation.

3.1.2.5 Electrical Power Interface

3.1.2.5.1 Power Connectors

The ACA will be supplied primary and backup power from the EPS on separate connectors as shown in Figure 5.

3.1.2.5.2 Primary/Backup Power

The ACA will be supplied primary/backup power that conforms to Paragraph 4.9 of D17389 (TRW SE19).

3.1.2.6 Communication, Command and Data Management Interface

3.1.2.6.1 Commands

The ACA will be supplied commands via an internally redundant RCTU from the AXAF-I CCDM subsystem.

3.1.2.6.2 Data transfer

All data will be transferred from the ACA to the AXAF-I CCDM subsystem through an internally redundant RCTU and an internally redundant IU.

3.1.2.6.3 PEA Power Relay

Primary power will be continuously supplied to the input filter of the PEA. A latching relay in the RCTU will provide a “PEA On” signal to the PEA regulator. When closed (PEA regulator inhibited), the relay will have a maximum impedance of < 1 ohm and a current carrying capacity of at least 1 ma. When open (PEA regulator enabled), it will exhibit an impedence of > 100 Kohms and will withstand a potential of at least 40 volts. See Paragraph 2.4 of D17387 and Figure 6.

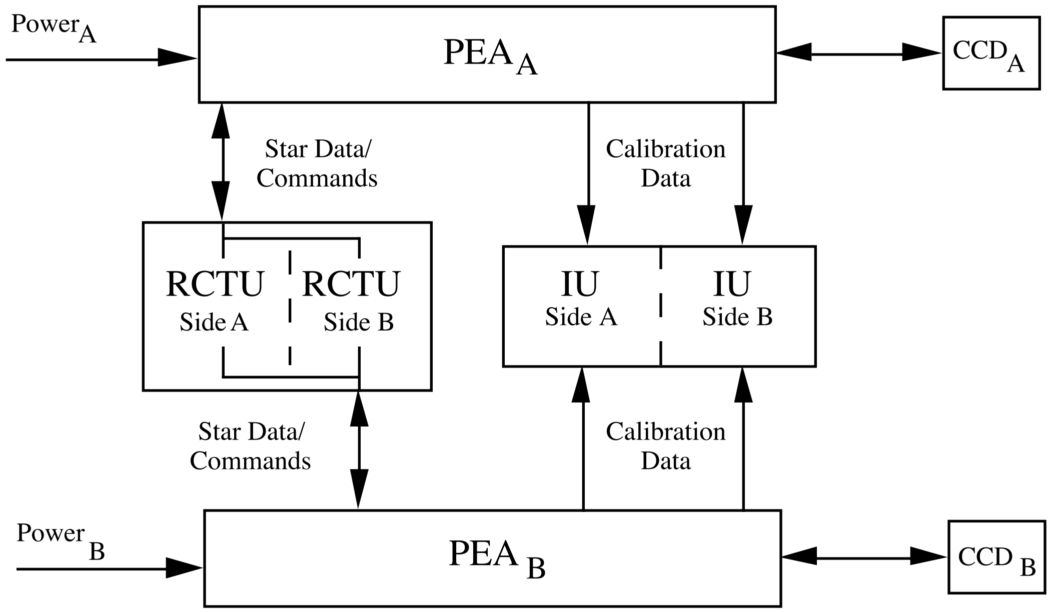


Figure 5. ACA Electrical Interfaces

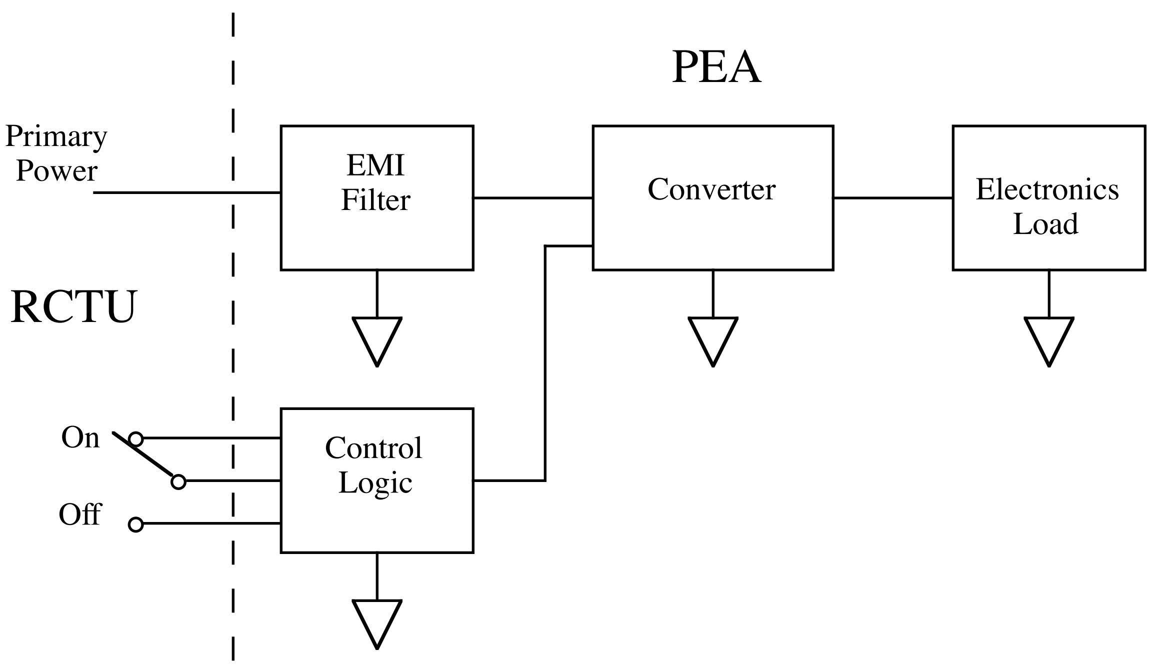


Figure 6. PEA Power Relay

3.1.2.6.4 Calibration Data Acquisition

An IU described in EQ29-0008 will provide for the acquisition of the formatted serial-digital calibration data defined in Section 3.2.1.15.13.

3.1.2.6.5 Flip Mirror Control

Each PEA of the ACA will receive two high level pulsed discrete commands through a channel of the PCAD RCTU to enable or disable power to the AC flip mirror driver. See Section 3.2.1.11.2 and Paragraph 2.2 of D17387. Each PEA of the ACA will also receive two low level discrete commands through a channel of the PCAD RCTU to command the flip mirror to either the deployed or stowed position.

3.1.2.7 Mechanical Interface

3.1.2.7.1 Mechanical Interface Definitions

The ACA mechanical interfaces with the TS are defined in five TRW interface control drawings. The AC mechanical interfaces are defined in TRW Drawing C301172. The SLS mechanical interfaces are defined in TRW Drawing C301173. The PEA mechanical interfaces are defined in TRW Drawing C301174. The cabling mechanical interfaces are defined in TRW Drawing C301326. The AC to FTM mechanical interfaces are defined in TRW Drawing 301160 and in Paragraphs 3.2.2.1.3 and 3.2.2.7 of IF1-29. Connector locations, connector types, and pin assignments are defined in TRW Drawings C301172, C301174 and C301326.

3.1.2.7.2 Line-of-Sight to the HRMA Door

The mechanical design of the AXAF-I will ensure the HRMA sunshade door is at least 20 deg from the AC line-of-sight when the HRMA door is open.

3.1.2.7.3 (Reserved)

3.2 Characteristics

3.2.1 Performance

Errors in the image position data specified in Section 3.2.1.15.11 affect spacecraft pointing and are called real-time errors. Errors in the pixel data specified in Section 3.2.1.15.12 affect aspect determination and are called post facto errors. Post facto processing uses updated calibration data and more sophisticated algorithms to determine image positions.

The error budget for star and fiducial light images is divided into spatial and temporal components. Temporal errors are variations over time at a single location in the field of view while staring at an unchanging scene. Spatial errors are variations over the field-of-view while staring at an unchanging scene that would remain if temporal errors were zero.

3.2.1.1 Error Allocations

Table I shows one-axis spatial and temporal error allocations (1σ) for star and fiducial light images for both real-time and post facto data processing. Table I applies for one measurement of an image, with an update period of 2.050 seconds, after the warm-up time defined in Section 3.2.1.6, at end-of-life, and only when the ACA is tracking an image as bright as the limiting magnitude defined in Section 3.2.1.13.2 and the star rate does not exceed 0.6 arc second per second. If the star rate exceeds 0.6 arc second per second but does not exceed 4.0 arc seconds per second and all

Table I. One-Axis Error Allocations

Parameter	Spatial Error (arc sec 1σ)	Temporal Error (arc sec 1σ)
Single Star (At limiting star magnitude, see Section 3.2.1.13.2)		
• Real-Time (on-orbit)	0.80	0.36
• Post Facto (ground processing)	0.20	0.36
Single Fiducial		
• Real-Time (on-orbit)	0.80	0.06
• Post Facto (ground processing)	0.14	0.06

Note: The post facto error allocations stated above apply for the modified 6 x 6 pixel array described in Section 3.2.1.11.1.4.

other aforementioned conditions are met, the real-time error allocations shall be 1.0 arc second (1σ), each, for spatial and temporal errors, and there is no post facto error requirement. Errors shall not exceed these limits after exposure to the environments specified in Section 3.2.5.1, nor during or after those specified in Section 3.2.5.2, nor with the additional stars referenced in Section 3.2.1.2 in the FOV.

3.2.1.2 Star Background

The presence of bright stars in the FOV shall not degrade accuracy beyond that specified in Section 3.2.1.1. Saturation of one or more pixels shall not deteriorate the performance for a star within the same quadrant centered four or more columns away from all saturated pixels.

3.2.1.3 Image Intensity Dynamic Range

The ACA shall have an image intensity dynamic range of 4 instrument magnitudes brighter than the dimmest star being tracked.

3.2.1.4 (Reserved)

3.2.1.5 (Reserved)

3.2.1.6 Warm-up Time

The error allocations specified in Section 3.2.1.1 shall apply after a warm-up period of no more than two hours, following power turn-on.

3.2.1.7 Timing

3.2.1.7.1 Update Period

The ACA shall update output data in the search function every 1.025 seconds. Updates shall occur 1.0 ± 0.5 msec prior to an RCTU science header pulse and 1.0 ± 0.5 msec prior to the midpoint between two RCTU science header pulses. See Figure 7. The beginning of integration shall be adjusted in time so that integration will always end within 1 msec of a science header pulse or within 1 msec of the midpoint between two science header pulses. RCTU science header pulses are described in Paragraph 3.1.2.1.3.5 of EQ29-0008.

3.2.1.7.2 Update Intervals for Pixel Data

Pixel data for each image shall be commandable in the search function (see Section 3.2.1.10.1) as either a 4 x 4 array, a modified 6 x 6 array (i.e. without the four corner pixels) or an 8 x 8 array; see Section 3.2.1.11.1.4. The ACA shall update 4 x 4 pixel array data in the search or track functions every 1.025, 2.050, 3.075, or 4.100 seconds.

The ACA shall select the shortest update period consistent with the sum of flush, integration and readout times. The ACA shall completely update modified 6 x 6 pixel array data every 2.050, 3.075, or 4.100 seconds. Each complete update shall be done during two consecutive 1.025-second periods. The ACA shall completely update 8 x 8 pixel array data every 4.100 seconds.

3.2.1.7.3 Extended Update Intervals

A series of data requests from the first ACA-dedicated RCTU port and from the second ACA-dedicated RCTU port will exhaust the data listed in Sections 3.2.1.15.11 and 3.2.1.15.12, respectively, during each 1.025-second period commencing or ending with an RCTU science header pulse. When the choice of integration time causes the update period to exceed 1.025 seconds for a 4 x 4 image, 2.050 seconds for a modified 6 x 6 image or 4.100 seconds for an 8 x 8 image, the ACA shall repeat the image data most recently provided to the two ACA-dedicated RCTU ports until new image data is available. For modified 6 x 6 pixel data, the repeated image data is that data described in Table VIIIC. For 8 x 8 pixel data, the repeated image data is that data described in Table VIIIG.

3.2.1.8 (Reserved)

3.2.1.9 Dim Stars

The ACA shall be able to monitor (see Section 3.2.1.10.2) stars dimmer than the limiting star magnitude defined in Section 3.2.1.13.2. The error allocations specified in Section 3.2.1.1 do not apply for these dim stars.

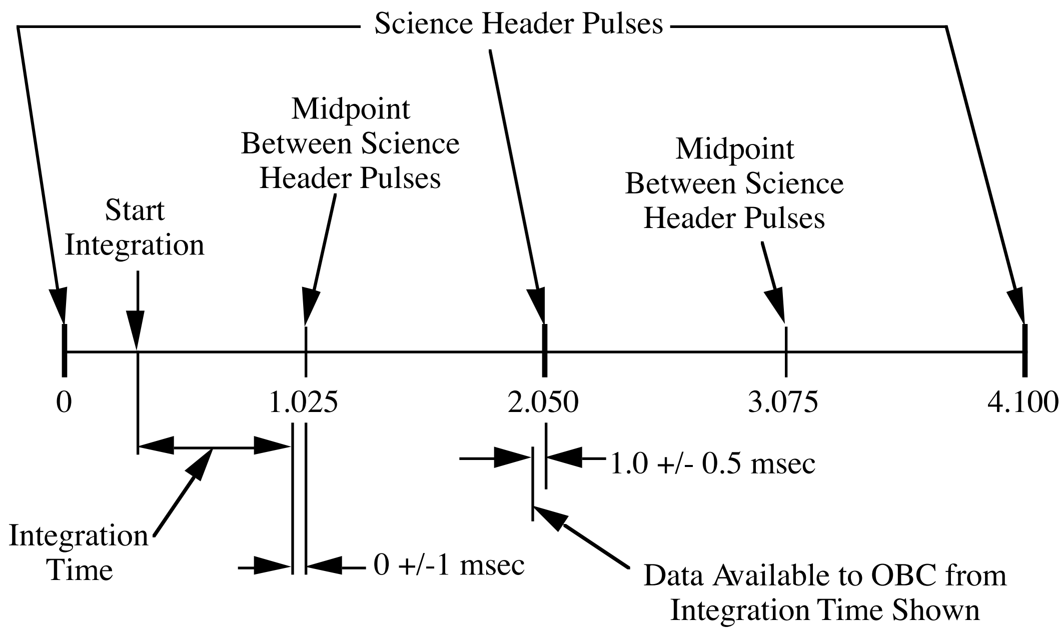


Figure 7. ACA-RCTU Timing

3.2.1.10 ACA Functions

The ACA shall have four basic flight functions — search, monitor, track and calibrate. The ACA shall simultaneously record up to 8 images; each one may be used independently with any of the flight functions except calibrate. The ACA shall have one function used both in flight and on the ground — extended command. Table II and Sections 3.2.1.10.1 to 3.2.1.10.5 describe these functions. Section 3.2.1.11.1.2 describes command formats.

3.2.1.10.1 Search

3.2.1.10.1.1 Definitions

The following definitions shall be used in specifying the ACA search operation.

3.2.1.10.1.1.1 Search Command

The complete three command word sequence specified in Section 3.2.1.11.1.3 shall define one search command.

Table II. Aspect Camera Functions

FUNCTION	TASK	INPUTS REQUIRED	OUTPUT(S) SUPPLIED
Search	Search commanded FOV or at directed locations for images	• Search command - Threshold - Criterion: - Brightness or Location - Image type - Star or Fiducial Light - Image number - Search Region Dimension - Search Region Location - Pixel output data array: - 4x4, modified 6x6, 8x8	• Function and statuses • Pixel Array Size
Monitor	Monitor dim stars at directed locations	Monitor command - Threshold - Convert to Track? - Image type - Image number - Monitor Location - Pixel output data array	• Image - pixel array size - pixel data - position - integration time • Function and statuses
Track	Track images	• None (automatically entered from search mode) • Revised integration time (optional)	• Image Same as Monitor plus - magnitude • Function and statuses
Calibrate	Calibrate detector array	• Calibrate command • Responsivity or dark current • Integration time • Positive or negative column numbers • Row numbers	• Individual pixel signals - magnitude - integration time • Function and statuses
Extended Command	Obtain diagnostic data	• Extended command	• Diagnostic data • Full Field Search • Function and statuses

3.2.1.10.1.1.2 Search Command Sequence

All consecutive search commands within one command group, as defined in Section 3.2.1.11.1.1, shall be a search command sequence.

3.2.1.10.1.1.3 Search Region

The search region for any image number shall be a square centered at the commanded angular Z and Y coordinates. (See Figure 1.) When the high resolution flag (H) in command word 3 is true (=1), the half-width of the square, in arc seconds, is (20 + 5D) where D is the dimension field in command word 2. (See Section 3.2.1.11.1.3.1.) When the H flag is false (=0), the half-width is (20 + 40D) arc seconds.

3.2.1.10.1.1.4 Candidate Images

Candidate images for each search region shall be defined as images within the region that are at least as bright as the commanded threshold for that region. The term "bright" in this definition refers to brightness as measured with the CCD and averaged over three consecutive CCD exposures. For some search regions there may be no candidate images.

3.2.1.10.1.1.5 Best Image

The best image for each search region shall be the brightest candidate image in that region if the B flag in command word 1 is true (=1), or the candidate image nearest the center of the search region if the B flag is false (=0). There will be no best image for those regions that have no candidate images.

3.2.1.10.1.1.6 Best Available Image

The best available image for any one region shall be defined as the best image for that region that is not assigned to any adjacent overlapping region for tracking. In the case of overlapping search regions, it is possible that there may be no best available image for a region, even though it does have a best image, since all candidate images may be assigned to adjacent overlapping regions.

3.2.1.10.1.2 Start of Search

Upon receipt of a search command sequence, the ACA shall do the following:

3.2.1.10.1.2.1 Terminate Previous Search

The ACA shall terminate any previously commanded search still in progress.

3.2.1.10.1.2.2 Continue Tracking and Monitoring

The ACA shall continue all tracking or monitoring operations for image numbers not addressed in the search command sequence.

3.2.1.10.1.2.3 Update Image Function Bits

The ACA shall set the image function bits (see Section 3.2.1.15.3) in the OBC data to the search state for all image data slots addressed in the search command sequence.

3.2.1.10.1.2.4 Initialize Command Progress

The ACA shall initialize the Command Progress (see Section 3.2.1.15.6.2) to a non-zero value indicating the approximate number of CCD rows to be searched as specified in Section 3.2.1.15.6.2.

3.2.1.10.1.2.5 Set Automatic Integration Time

The ACA shall automatically set the CCD integration time at the start of a search operation to a value that will allow acquisition at the dimmest threshold contained within the search command sequence.

3.2.1.10.1.2.6 Override Integration Time

If an integration time command within the same command group is appended to the end of a search command sequence, the ACA shall use the commanded integration time in lieu of the automatically set integration time specified above.

3.2.1.10.1.2.7 Search Commanded Regions

The ACA shall begin searching the commanded regions of the field-of-view for candidate images.

3.2.1.10.1.3 During Search

While the search is in progress, the ACA shall do the following:

3.2.1.10.1.3.1 Update Command Progress

The ACA shall keep the Command Progress updated to a non-zero value showing the approximate number of CCD rows remaining to be searched as specified in Section 3.2.1.15.6.2.

3.2.1.10.1.3.2 Initiate Tracking

The ACA shall convert the status of each image number from searching to tracking as soon as the best available image for that number is identified.

3.2.1.10.1.4 Completion of Search

At the completion of the search, the ACA shall do the following:

3.2.1.10.1.4.1 Zero Command Progress Bits

The ACA shall set the Command Progress bits to zero.

3.2.1.10.1.4.2 Update Image Function Bits

The ACA shall set the Image Function Bits (see Section 3.2.1.15.3) in the OBC data to “00” for all images addressed by the search command that were not converted to track status during the search.

3.2.1.10.1.5 Search Time

The ACA shall meet the search time specifications in the subparagraphs below when the integration time is automatically set by the ACA for a +10.2 magnitude threshold.

3.2.1.10.1.5.1 Full field with No Candidate Images

The maximum time required to complete the default search command sequence defined in section 3.2.1.11.1.3.2 shall not exceed 45 seconds when no candidate images are found in the full field-of-view.

3.2.1.10.1.5.2 Full Field with 16 Candidate Images

The maximum time required to complete the default search command sequence defined in section 3.2.1.11.1.3.2 shall not exceed 60 seconds when the field-of-view contains 16 uniformly distributed candidate images.

3.2.1.10.1.5.3 Minimum Size Search Areas

The maximum time required to complete a search command sequence consisting of eight search commands (see Section 3.2.1.11.1.3.1) with D set to 0 or 1 in each command and H set equal to 1, shall be 8 seconds when each search region contains one candidate image.

3.2.1.10.1.6 Image Rates

The ACA shall be successful in acquiring images that meet the commanded search criteria for image rates up to 8 arc seconds per second in any direction for any integration time that allows complete pixel data updates every 1.025 seconds.

3.2.1.10.2 Monitor

Upon receipt of a monitor command defined in Section 3.2.1.11.1.4, the ACA shall do the following:

3.2.1.10.2.1 Begin Monitoring

The ACA shall begin monitoring 8x8 blocks of CCD pixels centered on the commanded locations for the image numbers specified in the command(s).

3.2.1.10.2.2 Report Aspect Telemetry

While monitoring, the ACA shall report raw pixel images in the aspect telemetry data as either the central 4x4 or the central modified 6x6 or the full 8 x 8 block of pixels depending on the state of the S code in the monitor command. See Section 3.2.1.11.1.4.

3.2.1.10.2.3 Convert to Track

If an image appears within a monitored 8x8 pixel block with a brightness exceeding the commanded threshold, and if the C flag in the monitor command (see Section 3.2.1.11.1.4.) for that block is true (=1), then the ACA shall immediately convert the status of that image from monitoring to tracking.

3.2.1.10.2.4 Continue Monitoring

For all monitored images with false (=0) C flags in the monitor command, or brightnesses below the threshold, the ACA shall continue monitoring the commanded location until another command is received that changes the status of the image data slot.

3.2.1.10.2.5 Modification of Monitor Windows

The coordinates of each monitor window shall be modified over time to reflect motion of a designated tracked star (e.g. if the designated tracked star moves 5 arcsec along the +Y-axis of the AC, each monitor window shall move one column in the +Y direction on the AC focal plane). If no tracked image is designated as a star, all monitor windows shall remain fixed in AC coordinates. The star to be tracked is designated in the Monitor Command; see Section 3.2.1.11.1.4.

3.2.1.10.3 Track

The ACA shall track up to eight images and output the data specified in Sections 3.2.1.15.1 to 3.2.1.15.8 at the update rate specified in Section 3.2.1.7. The ACA shall continue to track any image found with a search command until it receives a command to another function for that image. The ACA shall use the integration time most recently commanded, if any; otherwise, the integration time last used in the search function.

Upon loss of an image within the FOV, the ACA shall attempt to track the image at its last known location. Upon recovery of the image, tracking shall continue. Upon loss of an image outside the FOV, the ACA shall cease tracking that image and await a new command for that image number.

3.2.1.10.4 Calibrate

The ACA shall implement two kinds of detector array calibration — one for responsivity, the other for dark current. The ACA shall not employ internal shutters nor require closure of the AXAF-I sunshade door. Data will be read out at a rate of 593.92 Kbits/sec and shall include start-of-frame and start-of-row codes. Calibration shall occur in blocks of consecutive complete rows within the same quadrant of the CCD. A row or column number of zero shall be treated as positive. Successive exposure frames will be used until all pixels are calibrated. For responsivity, extra rows will be calibrated in the next block for overlap with successive exposures. In order to assure adequate statistics, the entire CCD calibration may be replicated up to eight times ~~**for responsivity and up to two times for dark current**~~. Replicas shall be numbered consecutively starting with 0. **The replica number is for bookkeeping purposes only. No action is required other than reporting the replica number with the data as described in Section 3.2.1.15.13.**

3.2.1.10.5 Diagnostics - The Extended Command

Upon receipt of an extended command, the ACA shall perform the diagnostic tasks defined in Section 3.2.1.11.1.6.

3.2.1.11 Commands

3.2.1.11.1 Serial-Digital Commands

3.2.1.11.1.1 Command Word Groups

The ACA shall accept groups of 16-bit serial digital command words through the PCAD RCTU, separated in time as described in Section 3.1.2.1.7. See Paragraph 2.1 of D17387. The ACA shall execute all commands within the group sequentially except as specified in subsections below.

3.2.1.11.1.1.1 Command Checksum and Count

The ACA shall interpret the first word in each command word group as shown below, where the checksum and count fields are as described in Sections 3.1.2.1.8 and 3.1.2.1.9 respectively.

Checksum								0	0	Count					
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MSB															LSB

3.2.1.11.1.1.2 Command Error Processing

An invalid checksum indicates an error in transmission of a group of commands to the ACA. A syntax error indicates an invalid command was issued to the ACA.
If the checksum for any group of command words is invalid, or if a syntax error is detected in any command within the group, the error shall be reported as defined in Section 3.2.1.15.6.1, and the ACA shall not execute any command in the group.

3.2.1.11.1.1.3 Search Command Processing

Any search command sequence containing more than 8 consecutive 3-word search commands shall be treated as a syntax error. Any search command sequence not completely contained within one command word group shall be treated as a syntax error. If a command word group contains one or more search command sequences, the ACA shall ignore all commands in that group preceding the last search sequence.

3.2.1.11.1.1.4 Calibrate Command Processing

If a command word group contains calibrate commands, the ACA shall ignore all search and extended commands in the group preceding the first calibrate command.

3.2.1.11.1.2 Command Formats

Bits 0, 1, and 2 in the next diagram define the command. LSB and MSB are the least and most significant bits, respectively. Parameters in all command words shall be right justified.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MSB															LSB

Bits 0-2	Command
000	Not used
001	Search
010	Monitor
011	Calibrate
100	Extended Command
101	Set Integration Time
110	Data Input
111	Continuation of prior command

3.2.1.11.1.3 Search Command

3.2.1.11.1.3.1 Search Command Format

The search command consists of three consecutive words with parameter fields and format as shown below.

Symbol	Word	Bits	Description
T	1	3-10	Brightness threshold in the same format defined for star magnitude in the OBC telemetry data
B	1	11	Brightest image flag; specifies whether brightness (B=1), as opposed to position (B=0), is to be used as the best image selection criteria
F	1	12	Fiducial light flag; will be set true (=1) only if a fiducial light is expected to be the best available image for the search region defined by D, Z, and Y
I	1	13-15	Image number; specifies where data is to be reported in the OBC and aspect telemetry data.
D	2	0-5	Search region dimension; specifies the size of the search region as defined in section 3.2.1.10.1.1.3
Z	2	6-15	Z angle coordinate of center of search region; a 2's compliment number with one LSB representing 6.40 arc seconds
E	3	2	End flag: Set true (=1) only for the last command in a continuous sequence of search commands
H	3	3	High resolution flag for search region dimension; used with D to specify search region size as defined in section 3.2.1.10.1.1.3
S	3	4-5	Image size code: “0,0” specifies 4 x 4 pixel image for aspect data telemetry, “0,1” specifies modified 6 x 6 and “1,0” specifies 8 x 8. The pairing “1,1” is not used.
Y	3	6-15	Y angle coordinate of center of search region; a 2's compliment number with one LSB representing 6.40 arc seconds

First Word

0	0	1	Threshold (T)								B	F	Image (I)		
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MSB															LSB

Second Word

Dimension (D)						Signed-Z angle (Z)									
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MSB															LSB

Third Word

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	E	H	Size (S)		Signed-Y angle (Y)									
MSB															LSB

3.2.1.11.1.3.2 Default Search Command Sequence

At power turn-on the ACA shall immediately execute the default search command sequence.

The default search command sequence consists of eight consecutive search commands, one for each image data slot, with the parameters in each command set as follows:

Threshold:	+10.2 magnitude
Brightest image flag:	true (=1)
Fiducial light flag:	false (=0)
D = Dimension*:	$03F_{16}$
Z and Y-angles:	both 0
High resolution flag:	false (=0)
Size	"0,0"

*Half-width of square search area = 20 + 40*D arc seconds

The ACA shall preclude from tracking the same star (redundantly) in different image data slots. The eight brightest objects in the ACA FOV which exceed the threshold shall be tracked.

3.2.1.11.1.4 Monitor Command

The monitor command consists of three consecutive words with parameter fields and format as shown below.

Symbol	**Word**	**Bits**	**Description**
T	1	3-10	Brightness threshold in the same format defined for star magnitude in the OBC telemetry data
C	1	11	Convert-to-track flag; true (=1) specifies monitoring should be converted to tracking if and when the threshold is exceeded
F	1	12	Fiducial light flag; will be set true (=1) only if a fiducial light image is expected at the location to be monitored
I	1	13-15	Image number; specifies where data is to be reported in the OBC and aspect telemetry data.
S	2	4-5	Image size code: “0,0” specifies 4 x 4 pixel image for aspect data telemetry, “0,1” specifies modified 6 x 6 and “1,0” specifies 8 x 8. The pairing “1,1” is not used.
Z	2	6-15	Z angle coordinate of center of monitor region; a 2's compliment number with one LSB representing 6.40 arc seconds
Y	3	6-15	Y angle coordinate of center of monitor region; a 2's compliment number with one LSB representing 6.40 arc seconds
DTS	3	3-5	Designated Tracked Star; indicates which tracked image the monitor window will follow

First Word

0	1	0	Threshold (T)								C	F	Image (I)		
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MSB															LSB

Second Word

1	1	1	0	Size (S)		Signed Z-angle (Z)									
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MSB															LSB

Third Word

1	1	1	DTS			Signed Y-angle (Y)									
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MSB															LSB

3.2.1.11.1.5 Calibrate Command

For the calibrate command, bit 3 (C) defines the calibration type. "0" means dark current and "1" means responsivity. Bit 4 (P/N) specifies positive or negative column numbers; “0” means positive column numbers and “1” means negative column numbers. Bits 5-15 specify the starting row number. The rows read from the CCD in response to this command shall start with the specified row and progress towards row zero. One additional command word follows. It has a 111_2 in bits 0 to 2. Bits 3-5 specify the replica number in Section 3.2.1.10.4 and bits 6-15 specify the number of output rows. However, when bits 6-15 specify zero rows, this command shall terminate the calibrate function as specified in Section 3.2.1.16.1. All CCD charges shall be removed prior to integration. Integration time is set by the integration time command as discussed in Section 3.2.1.11.1.7. See the next diagrams.

0	1	1	C	P/N	Starting Row Number										
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MSB															LSB

1	1	1	Replica			Number of Rows									
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MSB															LSB

3.2.1.11.1.6 Extended Command

For the extended command, bit 3 is the continuation bit. "1" means that additional words follow this word, and "0" means that the command is complete.

When bit 3 is "1," bits 4-7 specify a Task Code and bits 8-15 specify the number of additional words that follow (1 to 62). See the next diagram.

1	0	0	1	Task Code				Count							
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MSB															LSB

Task Codes are:

Bits 4-7	Task
0	Reserved
1	Download
3	Execute Code Patch
2, ..., 15	Reserved

When bit 3 is "0," bits 4-7 specify a Test Code and bits 8-15 are Data Bits. See the next diagram.

1	0	0	0	Test Code				Data							
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MSB															LSB

Test Codes are:

Bits 4-7	Test
0	Check interface outputs
1, 2, 3	Reserved
4	Full Field Search (see Section 3.2.1.11.1.6.2)
5	IU Channel Select (see Section 3.2.1.11.1.6.3)
6, ..., 15	Reserved

3.2.1.11.1.6.1 Check Interface Outputs

Test Code "0" checks interfaces by continuously supplying output signals at specified interfaces. The Data Bits specify the following interfaces:

Bit	Interface checked
8	OBC Data (First ACA-dedicated RCTU port)
9	Telemetry Data (Second ACA-dedicated RCTU port)
10	Calibration Data (IU)
11, .., 15	Reserved

When bit 8 is "1," the ACA shall simulate for 8 images the OBC data specified in Section 3.2.1.15.11. Simulated values of these data shall be as follows: angle, 20000_{16}; magnitude, FF_{16}; image function and status, 00_{16}; event time, 00_{16}; Command Count, FF_{16}; Command Progress, FF_{16}; fid, "1"; and global status, as actually is.

When bit 9 is "1," the ACA shall simulate for 8 images the telemetry data specified in Section 3.2.1.15.12. Simulated values of these data shall be as follows: pixel data, $2AA_{16}$; scale factor, 0001_{16}; image function and status, 00_{16}; event and integration times, 00_{16}; row and column numbers, $1FF_{16}$; background, $1FF_{16}$; Command Count, FF_{16}; Command Progress, FF_{16}; fid, "1"; and global status, as actually is.

When bit 10 is "1," the ACA shall send the filler data specified in Section 3.2.1.16.2 including start-of-frame and start-of-row words, except that the integration time shall be $FFFF_{16}$.

When any Data Bit is "0," the ACA shall omit the interface check specified by that bit. When multiple Data Bits are "1," the interface checks shall be performed simultaneously.

3.2.1.11.1.6.2 Full Field Search Command

The full field search command is an extended command with bit 3 set to 0 and the test code set to 4. The data field of the command contains eight search flags, one for each of the eight image data slots. The search flags are arranged in order with bit 8 for image 0 and bit 15 for image 7.

Upon receipt of this command the ACA shall execute a search command sequence with one command for each image whose bit is set. Each of the search commands shall have the same parameters as defined for the default search command sequence in Section 3.2.1.11.1.3.2. The ACA shall not track the same star for two or more different image numbers.

3.2.1.11.1.6.3 IU Channel Select Command

The IU Channel Select Command is an extended command with bit 3 set to 0 and the test code set to 5. In all cases bits 8 through 14 shall be 0. If bit 15 is set to 0 the primary IU shall receive calibration data. If bit 15 is set to 1 the redundant IU shall receive calibration data.

3.2.1.11.1.6.4 Download Command

When the Task Code (bits 4-7) is “1” the ACA shall cause aspect image data to be replaced with memory dump data. The 3-word command format and interpretation are described below.

Word	Content				Description
1	1001	0001	0000	0010	
2	caaa	aaaa	aaaa	aaaa	C = PROM flag; true for download from the processor PROM; false for RAM. A = the 15 MSBs of the starting address for the download. **(The starting address must be an even number thus the LSB of the starting address must always be 0.)**
3	0000	0000	iiii	iiii	I = star image bit pattern to specify aspect image data slots to be used for downloading data (i=1). One bit corresponds to each image. The MSB represents image 7; the LSB represents image 0.

3.2.1.11.1.6.4.1 Download Function

The download command shall cause the ACA to download data from memory starting at the address specified in command word 2.

3.2.1.11.1.6.4.2 Data Location

The downloaded data shall replace image data in the aspect output data to the RCTU for each of the images specified in the command, starting with the lowest numbered image.

3.2.1.11.1.6.4.3 Data Bytes per Image

The first two bytes of each image data slot specified shall contain the memory address of the first memory location to be downloaded. This shall be followed by twenty-four 8-bit bytes of data, followed by a one byte checksum. (These are the 27 8-bit “Group Words” depicted in Table VIII.) Therefore, the total number of data bytes downloaded every 1.025 second data interval in response to one download command shall be 24 times the number of image slot flags set in the command.

3.2.1.11.1.6.4.4 Checksums

The one byte checksum specified in section 3.2.1.11.1.6.4.3 shall be computed so that the sum of the checksum plus the preceeding 26 bytes of data, modulo 256, shall be zero.

3.2.1.11.1.6.4.5 Download Duration

After receipt of this command, new download data shall replace aspect data each update period until another download command with all image bits set to zero is received or the last address in memory is reached, at which time the reporting of aspect data shall resume.

3.2.1.11.1.7 Integration Time Command

For the integration time command, bits 3-15 specify the integration time. The LSB shall be 16 milliseconds. The commanded integration time shall supersede the existing integration time. In the absence of this command, the track and calibrate functions shall use the integration time last commanded in any function. See the next diagram. This command may be used within any function.

1	0	1	Integration Time												
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MSB															LSB

3.2.1.11.1.8 Data Input Command

For the data input command, bits 3-7 define a data location and bits 8-15 specify the number of data words to follow.

1	1	0	Location					Data Count							
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MSB															LSB

Location codes and data counts are:

Bits 3-7	Location	Data Count
0	IU Header	4
1	Instruction Address	3-62
2	CCD Temperature	1
3	CCD Parallel Shift Rate	1
4, ..., 31	Reserved	Reserved

3.2.1.11.1.8.1 IU Header Data

If Location is set to "0" the next three 16-bit words provide the new 48-bit constant "Header 1" described in Section 3.2.1.16.3. The eight most significant bits of the fourth data word provide the new 8-bit constant "Header 2" also described in Section 3.2.1.16.3.

3.2.1.11.1.8.2 Memory Upload

If Location is set to "1" the next 16-bit word contains a memory address to begin loading data.
(Note that the starting address for a memory upload must be an even number thus the LSB of this 16-bit word must always be 0.) The following "Data Count minus two" 16-bit words are data to be loaded into consecutive memory locations beginning with the memory address designated above. The final 16-bit word is a zero-sum check sum of all data including the Data Input Command itself. If the check sum fails, memory shall not be modified and Global Status bit ~~5~~ **7, Syntax Error,** shall be set "true." ~~**Otherwise it shall be set "false."**~~
Note: The minimum Data Count is 3 since there must be one word each for the starting memory address, at least one data word, and the final word which must be the checksum. The maximum Data Count is 62 since this is a count of the number of words following the first word and the maximum number of words in a command group (even if there is only one command in the group) is 63; see Section 3.1.2.1.8. Therefore, the maximum number of data words per command is 60.

3.2.1.11.1.8.3 CCD Temperature Control

If Location is set to "2" the next 16-bit word shall be as defined below.

P	0	0	0	0	0	0	0	CCD Temperature							
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MSB															LSB

If P is true (=1), TEC power shall be commanded "on" and if false (=0) TEC power shall be commanded "off." (Default = "off.") CCD temperature shall be expressed in degrees C, signed, 2's compliment. Range = -128 deg C to +127 deg C. **The ACA design may dictate that allowable CCD temperature values occupy only part of this range. Command of a non-allowed temperature value is a syntax error.**

3.2.1.11.1.8.4 CCD Parallel Shift Rate Control

If Location is set to "3" the next 16-bit word shall indicate the CCD parallel shift rate. The LSB
shall be 1 microsecond. (Default = 24 microseconds.) Allowable values shall be 6, 12, ~~**18 and**~~ 24 **and 48** microseconds. **Command of a non-allowed value is a syntax error.**

3.2.1.11.2 High Level Discrete Commands

High level discrete commands shall be used to enable/disable flip mirror power.

3.2.1.11.3 Low Level Discrete Commands

Low level discrete commands are functional only when flip mirror power is enabled. See Section 3.2.1.11.2. Within 30 minutes of receipt of low level discrete command DC-1, the ACA shall remove the flip mirror from the optical path (primary FPA). Within 30 minutes of receipt of low level discrete command DC-2, the ACA shall insert the flip mirror in the optical path (redundant FPA).

3.2.1.12 Data

The ACA shall send all the image data defined in Sections 3.2.1.15.1 to 3.2.1.15.8 to the PCAD RCTU. See Paragraph 3.1 of D17387. The ACA shall send all the calibration data defined in Sections 3.2.1.15.9 and 3.2.1.15.10 to the IU. See Section 3.2.1.16. All these data shall be sent MSB first.

3.2.1.13 Optical Requirements

3.2.1.13.1 Spectral Sensitivity

For selection, identification, spectral class, and celestial positions of stars, the Guide Star Catalog, version 1.1 shall be used. Optical characteristics of the FTP and fiducial light beams are defined in Paragraph 3.2.2.7 of IF1-29. A zero magnitude star has a total irradiance over all wavelengths of 2.50×10^{-12} W/cm^2. Zero instrument magnitude is defined as the AC response to a zero magnitude star of spectral class G0 V (6030° K).

3.2.1.13.2 Field-of-View and Limiting Star Magnitude

The FOV and limiting star magnitude shall provide a 95% probability (minimum) of detecting a minimum of 5 stars anywhere on the celestial sphere. The FOV and limiting magnitude shall be consistent with Paragraph 3.2.2.7 of IF1-29. Nominal values for the FOV, pixel angular subtense, and limiting star magnitude are 1.40 degrees square, 5.0 arc seconds, and 10.2 instrument magnitude, respectively.

3.2.1.13.3 Aperture

The AC effective aperture shall be compatible with the limiting star magnitude defined in Section 3.2.1.13.2, the error allocations defined in Section 3.2.1.1, and the fastest update rate defined in Section 3.2.1.7 for the track function.

3.2.1.13.4 AC Line-of-Sight Stability

The AC LOS is defined as a ray from a single on-axis star projected through the AC telescope and imaged at the origin of the FOV. The AC LOS shall be normal to a rigid mounting plane within 80 arc seconds (radial, 3 sigma) after exposure to any of the non-operating environments stated in Section 3.2.5.1. This tolerance includes original misalignments. The AC LOS shall remain stable with respect to its mounting surface to within 3 arcsec (radial, 3 sigma) in the operational environment stated in Section 3.2.5.2 over any six month period.

3.2.1.13.5 Bright Earth Recovery

The ACA shall meet performance requirements when the AC LOS is 20 degrees or more from the limb of the bright earth. During normal operation, the bright earth may track across the AC FOV. The ACA shall accept commands and return to normal operation 2 seconds after the bright earth limb is at least 20 degrees from the AC LOS.

3.2.1.13.6 Dark Earth/Moon Recovery

The ACA shall meet performance requirements when the AC LOS is 6.0 degrees or more from the dark earth/moon. During normal operation, the dark earth/moon may track across the AC FOV. The ACA shall accept commands and return to normal operation 2 seconds after the dark earth/moon is at least 6.0 degrees from the AC LOS.

3.2.1.13.7 Solar Angle and Field-of-View Intrusion

The ACA shall meet performance requirements when the AC LOS is 20 degrees or more from the HRMA sunshade door.

During an emergency, the sun may track across the AC FOV. The ACA shall survive an emergency mode where the sun tracks across the FOV at 0.5 arcminute per second and shall recover and accept commands and return to normal operation 2 seconds after the sun is at least 20 degrees from the AC LOS.

3.2.1.13.8 Fiducial Lights

The ACA shall be capable of simultaneously tracking a total of eight stars and fiducial lights. The maximum number of fiducial lights to be tracked is 4. Each fiducial light will meet the requirements of Section 3.1.2.2.3.

3.2.1.14 Thermal Control System

The telescope thermal environment, within which the ACA must function, is specified in Sections 3.2.5.1.6 and 3.2.5.2.3 and in Paragraph 3.2.2.3.3 of IF1-29. Given this thermal environment, the ACA shall provide the necessary thermal control required to maintain the performance specified in Section 3.2.1. Heaters may be used where it can be demonstrated that performance requirements cannot be met by passive techniques alone. The FPA may employ thermoelectric coolers for achieving the required focal plane temperature.

Heat transfer from the AC and PEA will be primarily by radiation to the telescope interior. The surface temperature of the SLS will be less than 20° C. Part of the SLS will radiate to space. The space thermal environment is defined in Paragraph 3.1.4.4.1 of EV1-8 (TRW SE29). The surface temperature of the AC shall not exceed 20° C. AC heater power shall not exceed 5 watts. The PEA shall not use heater power while operating.

3.2.1.15 Outputs

3.2.1.15.1 Star and Fiducial Positions

The row and column angle outputs shall cover the field-of-view defined in Section 3.2.1.13.2. The output for each star and fiducial light position shall be an 18-bit twos complement word with a LSB of 0.025 arc second.

3.2.1.15.2 Star and Fiducial Magnitudes

The instrument magnitude for each star or fiducial light shall be digitized to 8 bits and shall be accurate to 0.2 magnitude. The LSB shall be 1/16 magnitude and the scale shall be from -2.00 (00_{16}) to +13.94 (FF_{16}). This accuracy requirement applies only for images as least as bright as the limiting magnitude defined in Section 3.2.1.13.2.

3.2.1.15.3 Image Function and Status Data

Each image shall have two function bits. These bits shall indicate the conditions defined in Table III.

Table III. Image Function Bits

Image Function Bits	Meaning
00	Not searching, monitoring or tracking (Image not in use)
01	Tracking, image present
10	Searching or monitoring, image not acquired
11	Tracking, image lost

Each image shall have six status bits as defined in Table IV. A "1" indicates truth of the condition.

Table IV. Image Status Bits

Image Status Bit	Meaning
0	Saturated pixel(s)
1	Defective pixel(s)
2	Quadrant boundary
3	Common column with another image
4	Multiple stars suspected
5	Ionizing radiation suspected

3.2.1.15.4 (Reserved)

3.2.1.15.5 Global Status

The ACA shall provide an 8-bit global status with each set of star and fiducial light measurements and with each set of calibration data as defined in Table V. A "1" indicates truth of the condition. The “Reset Occurred” flag shall remain in the “1” state for 2.05 seconds following a reset.

Table V. Global Status Bits

Global Status Bit	Meaning
0	High background
1	RAM failure
2	ROM failure
3	Power supply failure
4	Calibration Failure
5	Check Sum Failure
6	Reset Occurred
7	**Syntax Error ~~Reserved~~**

3.2.1.15.6 Command Status Words

The ACA shall provide two 8-bit command status words, called Command Count and Command Progress, with each set of image measurements as described below.

3.2.1.15.6.1 Command Count

The command count shall remain zero except on the first two outputs to the OBC following receipt of the last word in a group of command words, as described in Section 3.2.1.11.1.1. When the command count is non-zero, the 6 highest order bits shall contain a copy of the count shown in Section 3.2.1.11.1.1.1. The next bit shall be 1 only if a syntax error is found in any of the commands in the group **(same as Global Status bit 7)**. The final bit shall be 1 only if the checksum for the command word group is invalid **(same as Global Status bit 5)**.

3.2.1.15.6.2 Command Progress

The first six bits of Command Progress is an 6-bit integer. One LSB is 16 CCD rows. Fractional values of Command Progress shall be rounded up to the next whole number so that Command Progress will not become zero until the function is completed. The last two bits shall be the number of 1.025-second periods for which the OBC data described in Section 3.2.1.15.11 has been repeated. If the number of such periods exceeds three, the last two bits of Command Progress shall remain 1,1 until new data is available.

During a search, Command Progress bits shall represent the approximate number of CCD rows remaining to be searched.

During a calibration, Command Progress bits shall indicate the approximate number of rows of CCD data remaining to be read.

3.2.1.15.7 Integration Time, Track

The ACA shall provide a 16-bit integration time with each set of star and fiducial light measurements. The LSB shall be 16 milliseconds.

3.2.1.15.8 Pixel Data, Track

3.2.1.15.8.1 Pixel Data Arrays

Pixel data may be commanded to be output in either a full 4 x 4 array, a modified 6 x 6 array or a full 8 x 8 array (see Section 3.2.1.11.1.4). These three possibilities are depicted in Figure 8. Pixel data shall be centered on each image and shall be digitized to 10 bits. For a 4 x 4 array or an 8 x 8 array, the lowest row and column numbers of the array shall be provided in 10 bits each. For a modified 6 x 6 array, the lowest row and column numbers of the central 4 x 4 portion of the array shall be provided in 10 bits each. For any of the three types of array, the lead pixel row and column numbers indicate the pixel designated “A1" in Figure 8 (8A, 8B or 8C as appropriate). (When an array contains pixels with negative row or column numbers, the lowest row or column number is the most negative row or column number.)

3.2.1.15.8.2 Average Background

The average background for any image shall be calculated by averaging the pixel data from pixels A1, B1, G1, H1, I4, J4, O4 and P4 in Figure 8C. This average shall be compared with the pixel data from each of the eight pixels that contributed to the average. If any of the comparisons yields a difference in excess of ±30% of the average, those pixels shall be designated as outliers and the average shall be recalculated without the data from the one furthest outlier. This process shall be repeated until no more outliers are found.

3.2.1.15.8.3 RMS Background

The rms value of the background pixel data, about the average, shall be calculated based on N-1 degrees of freedom, where N equals the number of pixels in the calculations (i.e. 8 minus the number of outliers).

3.2.1.15.8.4 Pixel Data Scaling

The average background for the image shall be digitized to 10 bits. Each image shall have a 14-bit fixed binary scale factor with five places to the right of the binary point. The pixel data shall be offset and scaled so that Ne, the number of electrons given in a pixel is given by:

$$Ne = (\text{scale factor}) * (\text{pixel data}) - 250$$

P1	O1	N1	M1
L1	K1	J1	I1
H1	G1	F1	E1
D1	C1	B1	A1

Figure 8A. Pixel Designations for a 4 x 4 Array

	I2	J2	K2	L2	
H2	P1	O1	N1	M1	M2
G2	L1	K1	J1	I1	N2
F2	H1	G1	F1	E1	O2
E2	D1	C1	B1	A1	P2
	D2	C2	B2	A2	

Figure 8B. Pixel Designations for a 6 x 6 Array (Without Corners)

Figure 8. Aspect Data Pixel Designations (Page 1 of 2)

P4	O4	N4	M4	L4	K4	J4	I4
H1	G4	F4	E4	D4	C4	B4	A4
P3	O3	N3	M3	L3	K3	J3	I3
H3	G3	F3	E3	D3	C3	B3	A3
P2	O2	N2	M2	L2	K2	J2	I2
H2	G2	F2	E2	D2	C2	B2	A2
P1	O1	N1	M1	L1	K1	J1	I1
H1	G1	F1	E1	D1	C1	B1	A1

Figure 8C. Pixel Designations for an 8 x 8 Array

Figure 8. Aspect Data Pixel Designations (Page 2 of 2)

The scale factor shall be chosen such that the largest pixel data value is 1023. The rms value of the background shall be digitized to 10 bits using the same scale factor as above.

3.2.1.15.8.5 Background Pixel Outliers

The ACA shall provide an 8-bit word indicating which of the pixels nominally included in the background calculations have been included and which have been declared outliers, and thus excluded as shown in Table VI. A "1" indicates inclusion and a "0" indicates and excluded outlier.

Table VI. Background Pixel Status Bits

Background Pixel Status Bit	Pixel
0	A1
1	B1
2	G1
3	H1
4	I4
5	J4
6	O4
7	P4

3.2.1.15.9 Integration Time, Calibrate

The ACA shall provide a 16-bit integration time with each set of calibration data. The LSB shall be 16 milliseconds.

3.2.1.15.10 Pixel Data, Calibrate

The pixel data specified in Section 3.2.1.10.4 resulting from the calibrate function shall be provided through the IU as specified in Section 3.2.1.16. Pixel data shall be digitized to ~~12~~ **16** bits.

3.2.1.15.11 OBC Data Format

The data defined in Sections 3.2.1.15.1 to 3.2.1.15.7, **with the exception of Section 3.2.1.15.6.1,** will go to the OBC through the first ACA-dedicated RCTU port. It shall be formatted in 60 consecutive 8-bit words. Words 1 and 2 shall be the integration time currently in use. Word 3 shall be the global status. Word 4 shall be Command Progress. The remaining 56 words contain eight groups of seven words. Each group corresponds to a consecutively numbered image. Within each group the format shall conform to Table VII. "Fid" is "1" for a fiducial light and "0" for a star. The row and column angle data shall each be 20000_{16} and the magnitude data shall be FF_{16} when no star or fiducial light is found.

Table VII. OBC Data Format

<table>
<tr><th>Group Word</th><th>Bit 0</th><th>Bit 1</th><th>Bit 2</th><th>Bit 3</th><th>Bit 4</th><th>Bit 5</th><th>Bit 6</th><th>Bit 7</th></tr>
<tr><td>1</td><td>fid</td><td colspan="3">image number</td><td colspan="2">function *</td><td colspan="2">6 bits</td></tr>
<tr><td>2</td><td colspan="4">of image status †</td><td colspan="4">18 bits</td></tr>
<tr><td>3</td><td colspan="8">of signed</td></tr>
<tr><td>4</td><td colspan="6">row angle data</td><td colspan="2">18 bits</td></tr>
<tr><td>5</td><td colspan="8">of signed</td></tr>
<tr><td>6</td><td colspan="8">column angle data</td></tr>
<tr><td>7</td><td colspan="8">8 bits of magnitude data</td></tr>
</table>

* See Table III. † See Table IV.

3.2.1.15.12 Aspect Data Format

The data defined in Sections 3.2.1.15.3 to 3.2.1.15.8 will go to telemetry through the second ACA-dedicated RCTU port for use in post facto aspect determination. It shall be formatted in 224 consecutive 8-bit words. Words 1 and 2 shall be the integration time currently in use. Word 3 shall be the global status. Word 4 shall be Command Count. Word 5 shall be Command Progress. Words 6, 7 and 8 shall specify the type of pixel array data being reported for each image. Each image is assigned three bits in words 6, 7 and 8 . The assignments are shown below:

Word 6

<table>
<tr><td>Bit 0</td><td>Bit 1</td><td>Bit 2</td><td>Bit 3</td><td>Bit 4</td><td>Bit 5</td><td>Bit 6</td><td>Bit 7</td></tr>
<tr><td colspan="3">Image 0</td><td colspan="3">Image 1</td><td colspan="2">Image 2...</td></tr>
</table>

Word 7

<table>
<tr><td>Bit 0</td><td>Bit 1</td><td>Bit 2</td><td>Bit 3</td><td>Bit 4</td><td>Bit 5</td><td>Bit 6</td><td>Bit 7</td></tr>
<tr><td>Image 2</td><td colspan="3">Image 3</td><td colspan="3">Image 4</td><td>Image 5</td></tr>
</table>

Word 8

<table>
<tr><td>Bit 0</td><td>Bit 1</td><td>Bit 2</td><td>Bit 3</td><td>Bit 4</td><td>Bit 5</td><td>Bit 6</td><td>Bit 7</td></tr>
<tr><td colspan="2">...Image 5</td><td colspan="3">Image 6</td><td colspan="3">Image 7</td></tr>
</table>

For a given image, the three bits assigned to that image shall be “0,0,0” if a 4 x 4 array is to be reported, shall be “0,0,1” if the first half of a modified 6 x 6 array is to be reported or shall be “0,1,0” if the second half of a modified 6 x 6 array is to be reported for that image. The three bits assigned to that image shall be “1,0,0” if the first segment of an 8 x 8 array is to be reported, “1,0,1” for the second segment, “1,1,0” for the third segment and “1,1,1” for the fourth segment. The triad “0,1,1” shall be used to indicate that the corresponding aspect image data slots contain memory download data instead of aspect image data. (See section 3.2.1.11.1.6.4.)

The remaining 216 words shall contain eight groups of 27 words. Each group corresponds to a consecutively numbered image. Within each group the format shall conform to Table VIIIA for a 4 x 4 output array, Tables VIIIB and VIIIC for the first and second halves, respectively, of a modified 6 x 6 output array and Tables VIIID through VIIIG for the first, second, third and fourth segments, respectively, of an 8 x 8 output array. "Fid" shall be "1" for a fiducial light and "0" for a star. The output array defined in Section 3.2.1.15.8.1 shall be centered at the center of the search window when no star or fiducial light is found with a search command. All the pixel data defined in Section 3.2.1.15.8.1 shall be zero when no star or fiducial light is found with a search command.

Eight-bits of A/D counts representing the temperature measurements listed in Table IX shall be reported whenever pixel data is commanded to be output in either a modified 6x6 or an 8 x 8 array. The scale factor and range of the counts representing each of these temperatures shall be calibrated and reported for use by ground operators.

Table IX. Temperatures to be Reported in Aspect Data

Temperature Mnemonic	Measured Location
TEMP 1	CCD
TEMP 2	AC Housing
TEMP 3	Lens Cell
TEMP 4	Secondary Mirror

Table VIIIA. Aspect Data Format, 4 x 4 Array
(Refer to Figure 8A)

<table>
<tr><th>Group Word</th><th>Bit 0</th><th>Bit 1</th><th>Bit 2</th><th>Bit 3</th><th>Bit 4</th><th>Bit 5</th><th>Bit 6</th><th>Bit 7</th></tr>
<tr><td>1</td><td>fid</td><td colspan="3">image number</td><td colspan="2">function*</td><td colspan="2">6 bits</td></tr>
<tr><td>2</td><td colspan="4">of image status†</td><td colspan="4">row</td></tr>
<tr><td>3</td><td colspan="6">number of lead pixel (i.e.pixel “A1”)</td><td colspan="2"></td></tr>
<tr><td>4</td><td colspan="8">column number of lead pixel (i.e. pixel“A1”)</td></tr>
<tr><td>5</td><td colspan="8">scale</td></tr>
<tr><td>6</td><td colspan="6">factor</td><td colspan="2">average</td></tr>
<tr><td>7</td><td colspan="8">background for window</td></tr>
<tr><td>8</td><td colspan="2">signal in</td><td colspan="6"></td></tr>
<tr><td>9</td><td colspan="2">pixel “A1”</td><td colspan="2">signal in</td><td colspan="4"></td></tr>
<tr><td>10</td><td colspan="4">pixel “B1”</td><td colspan="2">signal in</td><td colspan="2"></td></tr>
<tr><td>11</td><td colspan="6">pixel “C1”</td><td colspan="2">signal in</td></tr>
<tr><td>12</td><td colspan="8">pixel “D1”</td></tr>
</table>

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•
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<table>
<tr><td>23</td><td colspan="2">signal in</td><td colspan="6"></td></tr>
<tr><td>24</td><td colspan="2">pixel “M1”</td><td colspan="2">signal in</td><td colspan="4"></td></tr>
<tr><td>25</td><td colspan="4">pixel “N1”</td><td colspan="2">signal in</td><td colspan="2"></td></tr>
<tr><td>26</td><td colspan="6">pixel “O1”</td><td colspan="2">signal in</td></tr>
<tr><td>27</td><td colspan="8">pixel “P1”</td></tr>
</table>

* See Table III. † See Table IV.

Table VIIIB. Aspect Data Format, First Half of a 6 x 6 Array
(Refer to Figure 8B)

Group Word	Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7
1	fid	image number			function*		6 bits	
2	of image status†				row number			
3	of lead pixel (i.e. pixel "A 1")							
4	column number of lead pixel (i.e. pixel "A 1")							
5	scale							
6	factor						average	
7	background for window							
8	signal in pixel "A1"							
9			signal in pixel "B1"					
10					signal in			
11	pixel "C1"						signal in	
12	pixel "D1"							

•
•
•

Group Word	Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7
23	signal in pixel "M1"							
24			signal in pixel "N1"					
25					signal in			
26	pixel "O1"						signal in	
27	pixel "P1"							

* See Table III. † See Table IV.

Table VIIIC. Aspect Data Format, Second Half of a 6 x 6 Array
(Refer to Figure 8B)

<table>
<tr><th>Group Word</th><th>Bit 0</th><th>Bit 1</th><th>Bit 2</th><th>Bit 3</th><th>Bit 4</th><th>Bit 5</th><th>Bit 6</th><th>Bit 7</th></tr>
<tr><td>1</td><td>fid</td><td colspan="3">image number</td><td colspan="2">function*</td><td colspan="2">rms</td></tr>
<tr><td>2</td><td colspan="8">background for window</td></tr>
<tr><td>3</td><td colspan="8">TEMP 1</td></tr>
<tr><td>4</td><td colspan="8">TEMP 2</td></tr>
<tr><td>5</td><td colspan="8">TEMP 3</td></tr>
<tr><td>6</td><td colspan="8">TEMP 4</td></tr>
<tr><td>7</td><td colspan="8">Background Pixel Status</td></tr>
<tr><td>8</td><td colspan="8">signal in pixel “A2”</td></tr>
<tr><td>9</td><td colspan="2"></td><td colspan="6">signal in pixel “B2”</td></tr>
<tr><td>10</td><td colspan="4"></td><td colspan="4">signal in</td></tr>
<tr><td>11</td><td colspan="6">pixel “C2”</td><td colspan="2">signal in</td></tr>
<tr><td>12</td><td colspan="8">pixel “D2”</td></tr>
</table>

•
•
•

<table>
<tr><td>23</td><td colspan="8">signal in pixel “M2”</td></tr>
<tr><td>24</td><td colspan="2"></td><td colspan="6">signal in pixel “N2”</td></tr>
<tr><td>25</td><td colspan="4"></td><td colspan="4">signal in</td></tr>
<tr><td>26</td><td colspan="6">pixel “O2”</td><td colspan="2">signal in</td></tr>
<tr><td>27</td><td colspan="8">pixel “P2”</td></tr>
</table>

* See Table III.

Table VIIID. Aspect Data Format, First Segment of an 8 x 8 Array
(Refer to Figure 8C)

Group Word	Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7
1	fid	image number			function*		6 bits	
2	of image status†				row number			
3	of lead pixel (i.e. pixel "A 1")							
4	column number of lead pixel (i.e. pixel "A 1")							
5	scale							
6	factor						average	
7	background for window							
8	signal in pixel "A1"							
9			signal in pixel "B1"					
10					signal in			
11	pixel "C1"						signal in	
12	pixel "D1"							
•								
•								
•								
23	signal in pixel "M1"							
24			signal in pixel "N1"					
25					signal in			
26	pixel "O1"						signal in	
27	pixel "P1"							

* See Table III. † See Table IV.

Table VIIIE. Aspect Data Format, Second Segment of an 8 x 8 Array
(Refer to Figure 8C)

Group Word	Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7
1	fid	image number			function*		rms	
2	background for window							
3	TEMP 1							
4	TEMP 2							
5	TEMP 3							
6	TEMP 4							
7	Background Pixel Status							
8	signal in pixel “A2”							
9			signal in pixel “B2”					
10					signal in			
11	pixel “C2”						signal in	
12	pixel “D2”							
•								
•								
•								
23	signal in pixel “M2”							
24			signal in pixel “N2”					
25					signal in			
26	pixel “O2”						signal in	
27	pixel “P2”							

* See Table III.

Table VIIIF. Aspect Data Format, Third Segment of an 8 x 8 Array
(Refer to Figure 8C)

Group Word	Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7
1	fid	image number			function*			
2								
3								
4				Not Defined				
5								
6								
7								
8				signal in pixel “A3”				
9				signal in pixel “B3”				
10					signal in			
11						pixel “C3”	signal in	
12							pixel “D3”	

•
•
•

Group Word	Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7
23				signal in pixel “M3”				
24				signal in pixel “N3”				
25					signal in			
26						pixel “O3”	signal in	
27							pixel “P3”	

* See Table III.

Table VIIIG. Aspect Data Format, Fourth Segment of an 8 x 8 Array
(Refer to Figure 8C)

Group Word	Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7
1	fid	image number			function*			
2	Not Defined							
3								
4								
5								
6								
7								
8	signal in pixel “A4”							
9			signal in pixel “B4”					
10					signal in			
11	pixel “C4”						signal in	
12	pixel “D4”							

•
•
•

Group Word	Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7
23	signal in pixel “M4”							
24			signal in pixel “N4”					
25					signal in			
26	pixel “O4”						signal in	
27	pixel “P4”							

* See Table III.

3.2.1.15.13 Calibrate Data Format

The calibration data stream will go to telemetry through the IU. It shall be formatted into records that are each comprised of 520 16-bit words. One row of CCD data shall be reported in each record. The first pixel data transmitted shall be from the pixel furthest from the origin of the focal plane, within the block of commanded data; see Figure 1. When normal calibration data is not available, fill data (defined below) shall be substituted in its place. Whenever fill data is substituted for actual data, fill data shall be sent in whole row records of 520 words, the same as CCD data. The term "calibration data" refers to the whole stream of data, including both CCD data and fill data, for as long as it takes to complete a sequence of calibration commands. Each record shall be formatted as follows:

Word 1: **Start of Record Synchronizing word = hex FF00**
(same value whether fill data or CCD data is being reported).

Word 2: **16-bit A/D converter zero offset (use hex AAAA for fill data).**

Word 3: **Integration time, as defined in Section 3.2.1.15.9**
(use hex AAAA for fill data).

Word 4: **C, Replica, and P/N parameters from the Calibrate Command**
(see Section 3.2.1.11.1.5) along with the CCD row number, packed into one 16-bit word as shown below
(use hex AAAA for fill data).

C	Replica			P/N	CCD Row Number										
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MSB															LSB

Words 5, 6, and 7:
Time Tag, 48-bits, 2 microsecond resolution; indicates start time for each row readout
(use hex AAAA AAAA AAAA for fill data).

Word 8: **Spare 16-bit word (value = hex AAAA).**

Words 9 - 520:
Pixel Data, as defined in Section 3.2.1.10.4, one 16-bit word for each pixel in one row of 512 pixels
(set all values to hex AAAA for fill data).

~~The data defined in Sections 3.2.1.15.9 and 3.2.1.15.10 will go to telemetry through the IU for post facto aspect determination. It shall be formatted into 8-bit words. The data shall be sent in complete rows of pixels in one quadrant. The first pixel data transmitted shall be from the pixel furthest from the origin of the focal plane, within the block of commanded data; see Figure 1. Data shall be sent starting with the specified row and progress towards row zero. There shall be two~~

~~16-bit synchronizing word types interspersed among the pixel data. The start-of-frame synchronizing word is $FF00_{16}$. It shall be sent at the beginning of each block of rows of pixel data. The integration time shall follow the start-of-frame word. Each row of pixel data shall start with the start-of-row synchronizing word shown below. P/N shall be "0" for positive columns and "1" for negative columns. C shall be "0" for dark current and "1," for responsivity. The replica number is defined in Sections 3.2.1.10.4 and 3.2.1.11.1.5. The pixel data for each row of 512 pixels shall follow its start-of-row word and shall be packed into the next 768 8-bit words. 32 rows shall follow each start-of-frame synchronizing word except that the last block in a series may have less than 32 rows.~~

~~0~~	~~C~~	~~Replica~~			~~P/N~~	~~Row Number~~									
~~0~~	~~1~~	~~2~~	~~3~~	~~4~~	~~5~~	~~6~~	~~7~~	~~8~~	~~9~~	~~10~~	~~11~~	~~12~~	~~13~~	~~14~~	~~15~~
~~MSB~~															~~LSB~~

3.2.1.15.14 Thermistors

The ACA shall have sixteen calibrated thermistor outputs representing the temperatures at the prime and redundant focal planes, the prime and redundant AC electronics, the prime and redundant PEAs, and ten other ACA locations. The outputs shall be read through the passive analog interface of the PCAD RCTU. See Paragraph 3.3 of D17387. Temperatures shall be accurate to 2 F deg.

3.2.1.15.15 Bilevels

The ACA shall have eight bilevel outputs to the PCAD RCTU with "1" representing true and "0," false for these eight statuses:

1. Primary PEA/FPA powered
2. Redundant PEA/FPA powered
3. Flip mirror set to primary FPA
4. Flip mirror set to redundant FPA
5. Calibrating

6-8. Reserved

Status 5 shall commence with execution of a calibrate command and shall end **upon receipt by the ACA of a calibrate command with the number of rows set to zero** ~~when the last block of data defined in Section 3.2.1.15.13 containing calibration data has been sent~~. Bilevel outputs shall be read through the PCAD RCTU. See Paragraph 3.4 of D17387.

3.2.1.16 Interface Unit (IU)

3.2.1.16.1 Channel Characteristics

The ACA shall send 256 ~~rows~~ **Calibration Records with** ~~of the~~ filler data **as** defined in Section ~~3.2.1.16.2~~ **3.2.1.15.13** immediately after receipt of the first of a series of calibrate commands to establish the communications channel. Thereafter, IU data transmission shall be continuous to maintain the communications channel. Whenever the calibration data is not available, the ACA shall send filler data instead. The ACA shall terminate IU data upon, and only upon, receipt of another calibrate command with the number of rows set to zero. ~~Termination of data transmission shall occur after transmission of the last record defined in Section 3.2.1.16.3 has been completed.~~

3.2.1.16.2 ~~Filler Data~~ **Reserved**

~~Filler data shall conform to Section 3.2.1.15.13 except that the start-of-row synchronizing word shall be 3801~~$_{16}$ ~~and all pixel data shall be AAA~~$_{16}$. ~~The integration time shall be the most recent integration time used by the ACA.~~

3.2.1.16.3 ~~Interface Unit Format~~ **Deep Space Network Record Format**

The calibration data stream defined in Section 3.2.1.15.13 shall be formatted into records for the Deep Space Network (DSN). Only complete DSN records are accepted. Each DSN record shall consist of:

1) **an 80-bit header, consisting of a 48-bit constant (Header 1), followed by a 24-bit record counter and completed by an 8-bit constant (Header 2). Header 1 and Header 2 will be preset by a data input command. The record counter shall initialize at zero at ACA turn-on and increment by one with each record sent.**

2) **a 1019 8-bit byte data block (see below) , and**

3) **1280 bits of A$_{16}$ replicated 320 times.**

The following steps shall be followed to fill the 1019 8-bit byte data block:

a) **The calibration data stream shall be divided into units of 509 16-bit words each.**

b) **The 1019-byte data block in each EVEN numbered DSN record shall be filled with 509 words of calibration data followed by AB$_{16}$.**

c) **The 1019-byte data block in each ODD numbered DSN record shall be filled with CD_{16} followed by 509 words of calibration data.**

~~The formatted data defined in Section 3.2.1.16.1 shall be formatted into records for the Deep Space Network. A record consists of an 80-bit header, followed by 8,152 bits of data, and completed by 1280 bits of A_{16} replicated 320 times. Only complete DSN records are accepted. The header word is a 48-bit constant (Header 1), followed by a 24-bit record counter and completed by an 8-bit constant (Header 2). Header 1 and Header 2 will be preset by a data input command. The record counter shall initialize at zero at ACA turn-on and increment by one with each record sent.~~

3.2.1.16.4 Calibration Failure

3.2.1.16.4.1 Calibration Failure Indication

If data is not read from the ACA by the IU at the nominal rate specified in Section 3.2.1.10.4, the ACA shall set the Calibration Failure bit "True" in the Global Status word defined in Section 3.2.1.15.5.

3.2.1.16.4.2 Duration of Calibration Failure

If the Calibration Failure bit is set "True" during any calibration sequence, it shall remain "True" until, and only until, receipt of the command specified in Section 3.2.1.16.1 to terminate calibration.

3.2.2 Physical Characteristics

3.2.2.1 Flip Mirror

The OBC will command the position of the flip mirror with the commands of Sections 3.2.1.11.2 and 3.2.1.11.3. The flip mirror shall be a part of the optical path to the redundant FPA, but not a part of the optical path to the primary FPA.

3.2.2.2 Mass Properties

The weight of the ACA shall not exceed 90 lbs, with maxima of 26.5 lbs for the AC, 21 lbs for both PEAs, 35 lbs for the SLS, and 7.5 lbs for the cabling.

3.2.2.3 Locations

Electrical circuits shall be located in the PEA to the maximum extent possible to minimize AC weight and FPA power dissipation.

3.2.2.4 Electrical Interface Requirements

Figure 5 shows the relationship of the ACA electrical subsystem to the EPS. Each PEA shall incorporate 5 separate connectors to support the following functions:

1) To connect to the EPS to receive primary power
2) To connect to the RCTU (both redundant halves) for receipt of commands and transmission of star data,
3) To connect to side A of the IU for transmission of pixel data,
4) To connect to side B of the IU for transmission of pixel data, and
5) To connect to one optical channel of the AC.

3.2.2.4.1 Power

The ACA and its heaters shall operate on an average power not exceeding 20 watts. The ACA shall not draw more than 25 watts peak power at any voltage in the range specified in Section 3.1.2.5.2.

3.2.2.4.2 Power Relay Signal

Power will be continuously supplied to the input filter of the PEA. The PEA shall be on in the presence of the power relay signal described in Section 3.1.2.6.3 and shall be off in its absence. See Figure 6.

3.2.2.5 Venting

Where necessary the ACA shall provide venting ports to prevent damage due to pressure changes during testing, transportation, launch, and landing. The launch and landing pressure profiles are defined in Paragraph 3.1.3.3 of EV1-8 (TRW SE29). Venting shall meet the requirements defined in Paragraph 4.1.1.5 of D17393 (TRW SE28) and avoid contamination of the HRMA.

3.2.2.6 Dynamics

The AC, PEA and SLS shall be designed so that their lowest natural frequencies are each greater than 50 Hz. This requirement applies to the AC and PEA when they are attached to a rigid structure at their interface mounting points. This requirement applies to the SLS when it is mounted on its support struts which, in turn, are attached to a rigid structure.

3.2.2.7 SLS Mounting Struts

SLS mounting struts shall be supplied that have the properties delineated on TRW drawing 301160.

3.2.2.8 (Reserved)

3.2.2.9 Mechanical Interface Requirements

The ACA shall meet all the mechanical interface requirements defined on TRW drawings 301172, 301173, 301174, 301326 and 301160.

3.2.3 Reliability

3.2.3.1 On-Orbit Life

The ACA shall be designed to attain a mission life of 5 years on orbit.

3.2.3.2 Shelf Life

Shelf life is defined as the period of time the ACA can retain its required performance and reliability characteristics prior to launch. The ACA shall be designed with a minimum shelf life of 4 years from date of delivery to TRW.

3.2.3.3 Redundancy

The ACA design shall contain no single point electrical, electromechanical or electronics failure which could degrade performance or propagate to other AXAF-I components.

3.2.4 Maintainability

3.2.4.1 Separable Assemblies

The AC, the PEA, the SLS and the cables shall be separable assemblies.

3.2.4.2 Access

Removal and replacement of the AC, SLS, and PEA shall not require shims or optical techniques. The AC mounting bracket is a part of the AXAF-I and not a part of the ACA.

3.2.5 Environmental Conditions

3.2.5.1 Non-Operating Environment

The ACA shall meet all the requirements of this specification after being subjected to any possible combination of the following non-operational environmental conditions.

3.2.5.1.1 Random Vibration, Non-Operating

The ACA will experience the random vibration defined in Paragraph 3.1.3.1.2 of EV1-8 (TRW SE29); Figures 3.1.3.1.2-4 and 3.1.3.1.2-8 define the PEA and AC/SLS spectra, respectively.

3.2.5.1.2 Acoustics, Non-Operating

The ACA will experience the acoustics defined in Paragraph 3.1.3.1.1 of EV1-8 (TRW SE29).

3.2.5.1.3 Shock, Non-Operating

The ACA shock spectra are shown in Figure 3.1.3.1.3.3 of EV1-8 (TRW SE29). The PEA experiences the “OB, SIM & IRU” level. The AC and SLS experience the “HRMA” level.

3.2.5.1.4 Transportation and Handling, Non-Operating

The ACA will experience the transportation and handling environments defined in Paragraph 3.1.2.1 of EV1-8 (TRW SE29).

3.2.5.1.5 Storage Environment, Non-Operating

The ACA will experience the storage environment defined in Paragraph 3.1.2.2 of EV1-8 (TRW SE29).

3.2.5.1.6 Temperature, Non-Operating

The ACA will experience the ground, launch, and prelaunch temperatures defined in Paragraph 3.1.4.4.2 of EV1-8 (TRW SE29). During survival conditions on orbit, the HRMA and OBA temperatures will be as defined in Paragraph 3.2.2.3.3 of IF1-29.

3.2.5.1.7 Pressure, Non-Operating

The ACA will experience the pressure defined in Paragraph 3.1.3.3 of EV1-8 (TRW SE29).

3.2.5.1.8 Quasi-static Load Factors, Non-Operating

The PEAs will experience the design limit loads defined in Table 4.0-6 of D22088 (TRW SE11i, Vol 1) during lift-off and abort landing. The AC and SLS will experience the design limit loads defined in Table 4.0-10 of D22088 during liftoff and abort landing. Angular accelerations experienced by the AC and SLS have been omitted from Table 4.0-10 because they are negligible.

3.2.5.1.9 Combined Loads, Non-Operating

The ACA will experience the combined loads defined in Paragraph 3.1.3.4 of EV1-8 (TRW SE29).

3.2.5.2 Operating Environment

The ACA shall meet the performance requirements of this specification during and after any possible combination of the following operational environments.

3.2.5.2.1 Temperature, Operating

The HRMA and OBA operating temperatures will be as defined in Paragraph 3.2.2.3.3 of IF1-29.

3.2.5.2.2 Pressure, Operating

The ACA will experience the pressure defined in Paragraph 3.1.4.1 of EV1-8 (TRW SE29).

3.2.5.2.3 Natural Environment, Operating

The ACA will experience the particle radiation environment and the meteoroid environment defined in Paragraphs 3.1.4.2 and 3.1.4.3 of EV1-8 (TRW SE29).

3.2.6 Transportability

ACA subsystems shall be transportable by common commercial carrier when packaged as described in Section 5.

3.3 Design and Construction

All flight hardware parts shall be procured to approved specifications. All parts shall be procured to approved drawings. Approved process specifications shall control critical manufacturing and assembly operations. All materials, parts and processes shall conform to the standards, specifications and procedures of MM-8070.2 and PAR700-272.

3.3.1 Parts, Materials, and Processes

Parts, materials and processes used in construction of the ACA shall meet the requirements defined in Paragraph 4.0 of PAR700-272.

3.3.1.1 Outgassing

All materials used in construction of the ACA shall meet the thermal-vacuum stability requirements of JSC-SP-R-0022.

3.3.1.2 Nuclear Radiation

Any materials, components or subsystems containing natural or man-made sources of nuclear radiation shall require prior approval from TRW.

3.3.1.3 Dissimilar Metals

When dissimilar metals, as defined in MSFC-SPEC-250, are in direct contact, their facing surfaces shall be adequately insulated by an approved sealing compound to assure protection from electrolytic corrosion. Additional organic finishing or barrier tapes may be used, subject to MSFC-SPEC-250.

3.3.1.4 Finish

The ACA finish shall conform to MSFC-SPEC-250, except for SLS baffle finishes.

3.3.1.5 Flammability

The ACA shall not use flammable materials without prior TRW approval. Material flammability shall be determined according to NHB-8060.1. The ACA design shall use MFSC-HDBK-527, which provides flammability characteristics of various materials.

3.3.1.6 Corrosion of Metal Parts

Metal parts shall be protected from corrosion by stress relieving, plating, anodizing, chemical coating, organic finishes, or a combination thereof, according to MSFC-SPEC-250, providing that such protection is compatible with the operating and space environmental requirements.

3.3.1.7 Corrosion Resistant Metals

Metals in contact with fluid media shall be corrosion resistant and shall be compatible with the media to which they are exposed. Use of metals and their weldments subject to embrittlement at cryogenic temperatures shall be avoided in all cryogenic applications.

3.3.1.8 Stress Corrosion

The requirements of MSFC-SPEC-522 shall apply for stress corrosion susceptibility of various metallic materials.

3.3.1.9 Contamination Control

The ACA shall be designed, fabricated, assembled, and tested according to D17393 (TRW SE28). All ACA components shall be baked out according to MSFC-SPEC-1238 prior to the verifications defined in Sections 4.3.3 and 4.3.4. The ACA shall be maintained in a Class 10,000 environment according to FED-STD-209. The ACA shall provide protective devices for subsequent transportation and integration and for the contamination environments specified in Paragraph 10.6 of NSTS 07700, Volume XIV, Attachment 1 (ICD 2-19001) and in JSC-SN-C-0005, Table A.1 (Level 500A).

3.3.1.10 Connector Usage

Connectors shall comply with Paragraphs 5.7.3 to 5.7.5 of PAR700-272. When a unit utilizes more than one connector, each connector shall be unique, either by choosing different sized or different shaped connectors for that unit or by the use of unique connector keying.

3.3.1.11 Flight Articles

3.3.1.11.1 Electrical

Wire used in cable harnesses shall conform to MIL-C-17, MIL-W-22759, and MIL-W-81381. Electrical wire insulation shall conform to MSFC-Ltr-EH02 (89-0782) and kapton insulated wire shall not be used for applications described therein. The ACA shall not use distribution and bussing junction devices. Crimping and wire wrap shall conform to NHB 5300.4(3H). Soldering shall conform to NHB 5300.4(3A-1). Printed circuit boards shall be designed according to NHB 5300.4(3K) and fabricated according to NHB 5300.4(3I). D22723 may be used as an alternative to NHB 5300.4(3I) and NHB 5300.4(3K). Conformal coating shall conform to NHB 5300.4(3J). Brazing shall conform to MIL-B-7883.

Redundant paths in the cabling shall be routed through separate connectors.

Electrical wiring harness assemblies shall conform to NHB 5300.4(3G) and be installed per MSFC-SPEC-494. Splices are not allowed without prior TRW approval. Protective circuitry shall be provided to ensure the safe and reliable operation of the electrical system and to prevent fault propagation and damage. Analog circuits which require remote signal conditioning shall be routed on a twisted-wire pair and shall not use structure as return. Continuity, insulation resistance, and dielectric withstanding voltage shall conform to NHB 5300.4(3G).

3.3.1.11.1.1 Electrical, Electronic and Electromagnetic Parts

Electrical, electronic and electromagnetic parts shall conform to Paragraph 4 of PAR700-272. The use of used parts is prohibited. Removed parts shall be replaced with new parts. Parts shall be derated according to MIL-STD-975. Circuit designs shall withstand worst case conditions with respect to part tolerances, environmental effects, end - of - life effects, and the extremes of input/output signals, and power. Information regarding MIL-STD-975 parts may be found in MIL-HDBK-978 (NASA).

3.3.1.11.1.2 Electrical Grounding

Electrical grounding shall conform to Paragraph 4.2 of D17389 (TRW SE19). The ACA is mounted on the telescope structure.

3.3.1.11.1.3 Corona Suppression

The ACA design shall conform to the corona suppression requirements defined in Paragraph 3.1.7 of EV1-8 (TRW SE29).

3.3.1.11.1.4 (Reserved)

3.3.1.11.1.5 Electrostatic Discharge Sensitive Elements

All electrical components utilizing electrostatic discharge sensitive elements shall conform to the requirements of subcontractor's plan for the control of electrostatic discharge. (See SDR SE19).

3.3.1.11.1.6 Minimum Dose Design Margin

The ACA shall be designed with a minimum end of life design margin of two (2) for all electronic parts. For those with a design margin of less than three (3), radiation lot acceptance testing per MIL-STD-883, Method 1019 shall be performed. Total design margin is defined as the ratio of the radiation level at which the part is derated to the predicted radiation level seen by the part at end of life. The total dose curve, without margin, for AXAF-I is shown in Figure 3.1.4.2.4 and Table 3.1.4.2.4 of EV1-8 (TRW SE29).

3.3.1.11.1.7 Rate of Upsets

The ACA electronics shall have less than one (1) upset per 30 days in the cosmic ray environment specified in Figure 3.1.4.2.5 of EV1-8 (TRW SE29). The upset rate includes the effects of error detection and correction coding and memory scrubbing, if applicable. An upset is defined as an unintended behavior that requires the issuance of one or more ground commands to correct.

3.3.1.11.1.8 Single Event Induced Latchups

There shall be no single event induced latchup or burnout in the anomalously large solar flare environment specified in Paragraph 3.1.4.2.5 of EV1-8 (TRW SE29). A latchup is defined as an unintended behavior that requires the ACA to be powered-down and restarted to correct.

3.3.1.11.2 Mechanical

3.3.1.11.2.1 Factors of Safety

All ACA structural elements shall be designed to the safety factors in MSFC-HDBK-505. Structural elements are those parts, including brackets, fasteners, and light shields, that experience loads during ground operations, launch, landing, ascent, or on-orbit operations. For nonmetallic structures, "A" values shall be developed using the statistical methods of MIL-HDBK-5.

3.3.1.11.2.2 Strength

The structure shall be designed to have sufficient strength to withstand the yield and ultimate loads, each with other accompanying environmental phenomena for each design condition. With TRW approval, certain nonmetallic materials may meet the ultimate loads criterion only. All nonmetallic flight structures require a static structural test. These tests shall be run on the appropriate structural assembly, subassembly, joint, or discontinuity area. Coupon tests to establish material allowables will not suffice to satisfy this structural test requirement. With TRW approval the contractor shall determine microyield design criteria for optically critical structures.

Glass and optical assemblies containing glass are special cases of nonmetals. For the structural verification of glass by analysis only, an ultimate safety factor of 5.0 shall be used. Specifications for glass components shall be submitted one month prior to preliminary design audit for approval by TRW.

For emergency landing loads, the structure may yield but not fracture.

3.3.1.11.2.3 Fasteners

Values used for fastener strength shall conform to MIL-HDBK-5. The limits of fastener capability shall include the effects of fastener preload, externally induced loads, and thermally induced loads. Installation and torque values for threaded fasteners shall conform to MSFC-STD-486 and MSFC-STD-557. Securing of threaded fasteners shall conform to MSFC-STD-561. Rivets and rivet type fasteners shall be installed according to MSFC-STD-156.

3.3.1.11.2.4 Fatigue and Fracture Mechanics

All structural elements shall withstand the effects of repeated loads and pressure cycles caused by ground handling, transportation and testing, two launches, and one return to Earth due to an aborted mission and subsequent transportation back to the launch site. D22095 (TRW SE33) shall be used to implement the requirements of MSFC-HDBK-505 and MSFC-HDBK-1453. All required nondestructive evaluation shall be performed according to MSFC-STD-1249.

3.3.1.11.2.5 Mating

All attachment points and surfaces except connectors shall be capable of being mated 50 times without degradation and without exceeding the dimensional, mounting surface flatness or coplanarity tolerances of TRW Drawings C301172, C301173, and 301160.

3.3.1.11.3 Optical

3.3.1.11.3.1 Scratch/Dig Requirements

For optical surfaces, scratch/dig requirements shall be defined per MIL-O-13830.

3.3.1.11.3.2 Aluminum or Aluminized Optical Surfaces

Aluminum or aluminized optical surfaces shall be manufactured per MIL-M-13508.

3.3.2 Electromagnetic Compatibility

The ACA shall meet the requirements of section 5.0 of D17389 (TRW SE19), the AXAF-I Electromagnetic Compatibility Control Plan.

3.3.3 Nameplate and Product Marking

ACA components shall be identified according to Paragraph 6.2 of PAR700-272.

3.3.4 Workmanship

Workmanship standards shall comply with MIL-STD-454. All contractor specifications shall contain a design and construction section detailing the specifications, standards and procedures to be used in the ACA.

3.3.5 Interchangeability

ACA subassemblies shall be interchangeable with respect to form, fit and function. In particular, any flight PEA shall be compatible with either AC optical channel.

3.3.6 Safety

The ACA shall meet the safety requirements of NSTS 1700.7, NSTS 18798 and PAR700-272.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 General

The verification program shall assure that ACA hardware and software conform to the requirements contained herein and to the requirements of PAR700-272. Each requirement specified or referenced in Sections 3.2 and 3.3 shall be verified by the method specified in this section.

4.1.1 Responsibility for Tests

The contractor is responsible for verifying compliance with all requirements specified herein. TRW reserves the right to have its personnel and/or its representatives observe all tests. TRW shall be notified at least three working days prior to any testing of the ACA.

4.1.2 Calibration Verification

The contractor shall maintain a calibration system according to MIL-STD-45662.

4.1.3 Verification Documentation

All verification documentation shall be readily available to inspection and test station personnel. The documentation shall also verify the calibration of the instruments used to perform the qualification and acceptance tests. All verification specifications and procedures shall be physically located at the applicable test station at the time of test.

4.1.4 Verification Conditions

All test conditions shall be as specified or referenced in this specification.

4.1.5 Failure Criteria

The unit shall exhibit no failure, malfunction or out-of-tolerance performance degradation as a result of the examinations and tests as specified herein. Any such failure, malfunction or out-of-tolerance performance or degradation shall be cause for rejection.

4.1.6 Test Reports

Test reports shall be prepared evaluating the results of tests following development, engineering model, protoflight, and acceptance testing.

4.1.7 Verification Methods

Protoflight and acceptance verification shall be accomplished by one or more of the following methods as specified in Table X.

A. Functional Tests
B. Environmental Tests
C. Similarity
D. Analysis
E. Inspection
F. Demonstration
G. Validation of Records

4.1.7.1 Functional Tests

Functional testing is an individual or series of performance tests conducted at conditions equal to or less than design specifications. Its purpose is to establish that the hardware performs satisfactorily according to design and performance specifications.

4.1.7.2 Environmental Tests

Environmental testing is an individual or series of tests conducted to assure that the hardware will perform satisfactorily in its flight environment. Protoflight units shall be tested to protoflight environmental levels and spare units shall be tested to acceptance levels. Environmental testing may or may not be combined with functional testing depending upon the test objectives. All environmental testing shall meet the requirements defined in Paragraphs 3.2 and 4.0 of EV1-8 (TRW SE29). The ACA is nonoperative during launch. EMC testing shall meet the requirements defined in Paragraph 6.0 of D17389 (TRW SE19) except that subparagraphs 6.2 and 6.3 do not apply.

4.1.7.3 Similarity

Verification by similarity assesses that the article is similar to or identical in design and manufacturing process to another article which was previously qualified to equivalent or more stringent specifications. The assessment shall review the test data or hardware configurations and applications.

4.1.7.4 Analysis

Verification by analysis may include systems engineering analysis, statistics and qualitative analysis, computer and hardware simulations and analog modeling. Analysis may be used when it can be determined that

- Rigorous and accurate analysis is possible,
- Test is not cost effective,
- Similarity is not applicable, and
- Verification by inspection is not adequate.

4.1.7.5 Inspection

Verification by inspection, e.g., physical verification of compliance with drawings, is a process which may be used to verify design features such as workmanship, dimensions, weight, physical condition or contamination.

4.1.7.6 Demonstration

Verification by demonstration is a process used to ensure that the hardware can perform observable functions in accordance with performance requirements such as serviceability, accessibility, transportability and human engineering requirements.

4.1.7.7 Validation of Records

Verification by validation of records uses manufacturing records at acceptance to verify construction features and processes for flight hardware.

4.1.8 Verification Facilities and Equipment

Existing facilities and equipment shall be utilized to the maximum extent practicable. Maximum use of the same equipment shall be made for testing at multiple locations to assure uniformity of test results. All test equipment shall be designed with a fail-safe goal that equipment failure cannot degrade flight hardware. All test equipment, including software/firmware, shall be verified prior to interfacing with flight equipment to ensure that no damage nor degradation to flight hardware can be induced.

4.1.9 Verification of Software/Firmware

All software/firmware which is a part of the ACA shall be verified according to Paragraph 8.0 of PAR700-272.

4.2 Quality Conformance Inspections

The Verification Matrix (Table X) defines protoflight and acceptance verification requirements for Sections 3.2 and 3.3 and the methods to be used to verify conformance. The Testing Sequence (Table XI) defines the order of AC/PEA and SLS tests.

4.2.1 Performance Test and Image Calibration

A performance test consists of all the tests listed in Table X citing method "A". The test shall include sufficient measurements over the field of view, temperature, image intensity, and source wavelength to verify that the ACA meets all requirements listed in Table X citing method "A". The test shall include one source with a polychromatic spectrum.

Image calibration consists of pixel data in a 8 x 8 window centered at an image location. The calibration shall include sufficient measurements over the field-of-view, temperature, image intensity and source wavelength to define the point spread function and optical distortion for post-facto processing.

A performance test and image calibration may be combined. A visual examination shall precede and follow the testing.

Table X

ASPECT CAMERA ASSEMBLY VERIFICATION MATRIX

Verification Method

A. Functional Test
B. Environmental Test
C. Similarity
D. Analysis
E. Inspection
F. Demonstration
G. Validation of records
N/A Not Applicable

Section	Title	Proto. Method	Accept. Method
3.2	Characteristics	N/A	N/A
3.2.1	Performance	N/A	N/A
3.2.1.1	Error Allocations	A	A
3.2.1.2	Star Background	A	A
3.2.1.3	Image Intensity Dynamic Range	A	A
3.2.1.6	Warm-Up Time	A	A
3.2.1.7	Timing	N/A	N/A
3.2.1.7.1	Update Period	A	A
3.2.1.7.2	Update Intervals for Pixel Data	A	A
3.2.1.7.3	Extended Update Intervals	A	A
3.2.1.9	Dim Stars	A	A
3.2.1.10	ACA Functions	A	A
3.2.1.10.1	Search	N/A	N/A
3.2.1.10.1.1	Definitions	N/A	N/A
3.2.1.10.1.1.1	Search Command	N/A	N/A
3.2.1.10.1.1.2	Search Command Sequence	N/A	N/A
3.2.1.10.1.1.3	Search Region	A	A
3.2.1.10.1.1.4	Candidate Images	N/A	N/A
3.2.1.10.1.1.5	Best Image	A	A
3.2.1.10.1.1.6	Best Available Image	A	A
3.2.1.10.1.2	Start of Search	N/A	N/A
3.2.1.10.1.2.1	Terminate Previous Search	A	A
3.2.1.10.1.2.2	Continue tracking and Monitoring	A	A
3.2.1.10.1.2.3	Update Image Function Bits	A	A
3.2.1.10.1.2.4	Initialize Search Status	A	A
3.2.1.10.1.2.5	Set Automatic Integration Time	A	A
3.2.1.10.1.2.6	Override Integration Time	A	A
3.2.1.10.1.2.7	Search Commanded Regions	A	A
3.2.1.10.1.3	During Search	N/A	N/A
3.2.1.10.1.3.1	Update Command Progress	A	A
3.2.1.10.1.3.2	Initiate Tracking	A	A
3.2.1.10.1.4	Completion of Search	N/A	N/A
3.2.1.10.1.4.1	Zero Command Progress Bits	A	A
3.2.1.10.1.4.2	Update Image Function Bits	A	A
3.2.1.10.1.5	Search Time	N/A	N/A
3.2.1.10.1.5.1	Full Field with No Candidate Images	A	A
3.2.1.10.1.5.2	Full Field with 16 Candidate Images	A	A
3.2.1.10.1.5.3	Minimum Size Search Areas	A	A

Table X (Continued)

ASPECT CAMERA ASSEMBLY VERIFICATION MATRIX

Verification Method

A. Functional Test
B. Environmental Test
C. Similarity
D. Analysis
E. Inspection
F. Demonstration
G. Validation of records
N/A Not Applicable

Section	Title	Proto. Method	Accept. Method
3.2.1.10.1.6	Image Rates	A	A
3.2.1.10.2	Monitor	N/A	N/A
3.2.1.10.2.1	Begin Monitoring	A	A
3.2.1.10.2.2	Report Aspect Telemetry	A	A
3.2.1.10.2.3	Convert to Track	A	A
3.2.1.10.2.4	Continue Monitoring	A	A
3.2.1.10.2.5	Modification of Monitor Windows	A	A
3.2.1.10.3	Track	A	A
3.2.1.10.4	Calibrate	A	A
3.2.1.10.5	Extended Command	A	A
3.2.1.11	Commands	N/A	N/A
3.2.1.11.1	Serial-Digital Commands	N/A	N/A
3.2.1.11.1.1	Command Word Groups	A	A
3.2.1.11.1.1.1	Command Checksum and Count	A	A
3.2.1.11.1.1.2	Command Error Processing	A	A
3.2.1.11.1.1.3	Search Command Processing	A	A
3.2.1.11.1.1.4	Calibrate Command Processing	A	A
3.2.1.11.1.2	Command Formats	N/A	N/A
3.2.1.11.1.3	Search Command	N/A	N/A
3.2.1.11.1.3.1	Search Command Format	A	A
3.2.1.11.1.3.2	Default Search Command Sequence	A	A
3.2.1.11.1.4	Monitor Command	A	A
3.2.1.11.1.5	Calibrate Command	A	A
3.2.1.11.1.6	Extended Command	A	A
3.2.1.11.1.6.1	Check Interface Outputs	A	A
3.2.1.11.1.6.2	Full Field Search Command	A	A
3.2.1.11.1.6.3	IU Channel Select Command	A	A
3.2.1.11.1.6.4	Download Command	A	A
3.2.1.11.1.6.4.1	Download Function	A	A
3.2.1.11.1.6.4.2	Data Location	A	A
3.2.1.11.1.6.4.3	Data Bytes per Image	A	A
3.2.1.11.1.6.4.4	Checksums	A	A
3.2.1.11.1.6.4.5	Download Duration	A	A
3.2.1.11.1.7	Integration Time Command	A	A
3.2.1.11.1.8	Data Input Command	A	A
3.2.1.11.1.8.1	IU Header Data	A	A
3.2.1.11.1.8.2	Memory Upload	A	A
3.2.1.11.1.8.3	CCD Temperature Control	A	A

Table X (Continued)

ASPECT CAMERA ASSEMBLY VERIFICATION MATRIX

Verification Method

A. Functional Test
B. Environmental Test
C. Similarity
D. Analysis
E. Inspection
F. Demonstration
G. Validation of records
N/A Not Applicable

Section	Title	Proto. Method	Accept. Method
3.2.1.11.1.8.4	CCD Parallel Shift Rate Control	A	A
3.2.1.11.2	High Level Discrete Commands	A	A
3.2.1.11.3	Low Level Discrete Commands	A	A
3.2.1.12	Data	A	A
3.2.1.13	Optical Requirements	N/A	N/A
3.2.1.13.1	Spectral Sensitivity	E	N/A
3.2.1.13.2	Field-of-View and Limiting Star Magnitude	A&D	A
3.2.1.13.3	Aperture	D	N/A
3.2.1.13.4	AC Line-of-Sight Stability	D	N/A
3.2.1.13.5	Bright Earth Recovery	D	N/A
3.2.1.13.6	Dark Earth/Moon Recovery	D	N/A
3.2.1.13.7	Solar Angle and Field-of-View Intrusion	D&A	N/A
3.2.1.13.8	Fiducial Lights	A	A
3.2.1.14	Thermal Control System	D	N/A
3.2.1.15	Outputs	N/A	N/A
3.2.1.15.1	Star and Fiducial Position	A	A
3.2.1.15.2	Star and Fiducial Magnitude	A	A
3.2.1.15.3	Image Function and Status Data	A	A
3.2.1.15.5	Global Status	A	A
3.2.1.15.6	Command Status Words	A	A
3.2.1.15.6.1	Command Count	A	A
3.2.1.15.6.2	Command Progress	A	A
3.2.1.15.7	Integration Time, Track	A	A
3.2.1.15.8	Pixel Data, Track	N/A	N/A
3.2.1.15.8.1	Pixel Data Arrays	A	A
3.2.1.15.8.2	Average Background	A	A
3.2.1.15.8.3	RMS Background	A	A
3.2.1.15.8.4	Pixel Data Scaling	A	A
3.2.1.15.8.5	Background Pixel Outliers	A	A
3.2.1.15.9	Integration Time, Calibrate	A	A
3.2.1.15.10	Pixel Data, Calibrate	A	A
3.2.1.15.11	OBC Data Format	A	A
3.2.1.15.12	Aspect Data Format	A	A
3.2.1.15.13	Calibrate Data Format	A	A
3.2.1.15.14	Thermistors	A	A
3.2.1.15.15	Bilevels	A	A
3.2.1.16	Interface Unit	N/A	N/A
3.2.1.16.1	Channel Characteristics	A	A
3.2.1.16.2	Filler Data	A	A

Table X (Continued)

ASPECT CAMERA ASSEMBLY VERIFICATION MATRIX

Verification Method

A. Functional Test	E. Inspection
B. Environmental Test	F. Demonstration
C. Similarity	G. Validation of records
D. Analysis	N/A Not Applicable

Section	Title	Proto. Method	Accept. Method
3.2.1.16.3	Interface Unit Format	A	A
3.2.1.16.4	Calibration Failure	N/A	N/A
3.2.1.16.4.1	Calibration Failure Indication	A	A
3.2.1.16.4.2	Duration of Calibration Failure	A	A
3.2.2	Physical Characteristics	N/A	N/A
3.2.2.1	Flip Mirror	A&B	A&B
3.2.2.2	Mass Properties	E	E
3.2.2.3	Locations	D	N/A
3.2.2.4	Electrical Interface Requirements	E	E
3.2.2.4.1	Power	A	A
3.2.2.4.2	Power Relay Signal	A	A
3.2.2.5	Venting	D	N/A
3.2.2.6	Dynamics	B&D	B
3.2.2.7	SLS Mounting Struts	E	E
3.2.2.9	Mechanical Interface Requirements	E	E
3.2.3	Reliability	N/A	N/A
3.2.3.1	On-Orbit Life	G	G
3.2.3.2	Shelf Life	D	N/A
3.2.3.3	Redundancy	A	A
3.2.4	Maintainability	N/A	N/A
3.2.4.1	Separable Assemblies	E	N/A
3.2.4.2	Access	F	N/A
3.2.5	Environmental Conditions	N/A	N/A
3.2.5.1	Non-Operating Environment	N/A	N/A
3.2.5.1.1	Random Vibration, Non-Operating	B	B
3.2.5.1.2	Acoustics, Non-Operating	B	B
3.2.5.1.3	Shock, Non-Operating	D	N/A
3.2.5.1.4	Transportation and Handling, Non-Operating	D	N/A
3.2.5.1.5	Storage Environmnet, Non-Operating	D	N/A
3.2.5.1.6	Temperature, Non-Operating	B	B
3.2.5.1.7	Pressure, Non-Operating	D	N/A
3.2.5.1.8	Quasi-static Load Factors, Non-Operating	D	N/A
3.2.5.1.9	Combined Loads, Non-Operating	D	N/A
3.2.5.2	Operating Environment	N/A	N/A
3.2.5.2.1	Temperature, Operating	B	B
3.2.5.2.2	Pressure, Operating	B	B
3.2.5.2.3	Natural Environment, Operating	D	N/A
3.2.6	Transportability	E	N/A
3.3	Design and Construction	G	G

Table X (Continued)

ASPECT CAMERA ASSEMBLY VERIFICATION MATRIX

Verification Method

A. Functional Test — E. Inspection
B. Environmental Test — F. Demonstration
C. Similarity — G. Validation of records
D. Analysis — N/A Not Applicable

Section	Title	Proto. Method	Accept. Method
3.3.1	Parts, Materials, and Processes	G	G
3.3.1.1	Outgassing	G	G
3.3.1.2	Nuclear Radiation	D	N/A
3.3.1.3	Dissimilar Metals	D	N/A
3.3.1.4	Finish	E	E
3.3.1.5	Flammability	D	N/A
3.3.1.6	Corrosion of Metal Parts	G	G
3.3.1.7	Corrosion Resistant Metals	G	G
3.3.1.8	Stress Corrosion	D	N/A
3.3.1.9	Contamination Control	G	G
3.3.1.10	Connector Usage	E	E
3.3.1.11	Flight Articles	N/A	N/A
3.3.1.11.1	Electrical	G	G
3.3.1.11.1.1	Electrical, Electronic and Electromagnetic Parts	G	G
3.3.1.11.1.2	Electrical Grounding	A	A
3.3.1.11.1.3	Corona Suppression	N/A	N/A
3.3.1.11.1.5	Electrostatic Discharge Sensitive Elements	G	G
3.3.1.11.1.6	Minimum Dose Design Margin	D	N/A
3.3.1.11.1.7	Rate of Upsets	D	N/A
3.3.1.11.1.8	Single Event Induced Latchups	D	N/A
3.3.1.11.2	Mechanical	N/A	N/A
3.3.1.11.2.1	Factors of Safety	D	N/A
3.3.1.11.2.2	Strength	B* or D	B*
3.3.1.11.2.3	Fasteners	D	N/A
3.3.1.11.2.4	Fatigue and Fracture Mechanics	B* or D	B*
3.3.1.11.2.5	Mating	E	E
3.3.1.11.3	Optical	N/A	N/A
3.3.1.11.3.1	Scratch/Dig Requirements	E	E
3.3.1.11.3.2	Aluminum or Aluminized Optical Surfaces	E	E
3.3.2	Electromagnetic Compatibility	B	N/A
3.3.3	Nameplate and Product Making	E	E
3.3.4	Workmanship	E	E
3.3.5	Interchangeability	D	N/A
3.3.6	Safety	F	N/A

* Non-metallic structures only

TABLE XI.

ASPECT CAMERA ASSEMBLY TESTING SEQUENCE

	AC/PEA	SLS
Performance Test and Image Calibration (Section 4.2.1)	All items	Inspect only
EMC Test (Paragraph 6.0 of D17389 (TRW SE19); references to MSFC are to TRW)	All items (protoflight only)	N/A
Limited Functional Test (Section 4.2.2)	All items (protoflight only)	N/A
Thermal-Vacuum (Paragraph 4.1.1.5 of EV1-8 (TRW SE29) and Section 4.2.2)	11 cycles All items	11 cycles, Non-operating
Limited Functional Test (Section 4.2.2)	All items	Inspect only
Random Vibration (Paragraph 4.1.1.6 of EV1-8 (TRW SE29)	All items	Non-operating
Limited Functional Test (Section 4.2.2)	N/A	Inspect only (protoflight only)
Acoustic Test (Paragraph 4.1.1.7 of EV1-8 (TRW SE29)	N/A	Non-operating
Performance Test and Image Calibration (Section 4.2.1)	All items	Inspect only

4.2.2 Limited Functional Test

A limited functional test assures that all electrical aspects of a unit are functioning properly. The test shall nclude all input channels, all output channels, the flip mirror, the soft switch, a continuous power monitor, and all primary and redundant paths. A visual examination shall precede and follow the testing.

4.3 Verification Requirements

4.3.1 Development Verification

Development verification is the process that verifies the feasibility of the design approach and provides confidence in the ability of the hardware to comply with the requirements specified in Sections 3.2 and 3.3. AC/PEA development verification shall include, but is not limited to, testing and assessment of the proposed detector array and tests of critical components. Testing and assessment of the proposed detector array shall include radiation modeling with radiation test data of the proposed detector array.

4.3.2 Engineering Model Verification

Engineering model verification for the AC/PEA consists of a performance test and image calibration defined in Section 4.2.1, a random vibration test defined in Paragraph 4.1.1.6 of EV1-8 (TRW SE29), followed by a second performance test and image calibration.

Engineering model verification for the SLS consists of a random vibration test and an acoustics test defined respectively in Paragraphs 4.1.1.6 and 4.1.1.7 of EV1-8 (TRW SE29).

4.3.3 Protoflight Verification

Protoflight verification is that which verifies that selected flight-type items meet the performance and design requirements under environments which are greater than anticipated, but less than design limits. Protoflight verification of the ACA shall include Section 4.2 to verify conformance to the requirements in Sections 3.2 and 3.3. It shall also include the tests listed in Sections 4.3.3.1 to 4.3.3.3. Protoflight verification of the ACA shall be performed prior to delivery to TRW.

4.3.3.1 Material Properties

Static structural tests of nonmetallic materials used in the ACA and referenced in Sections 3.3.1.11.2.1 and 3.3.1.11.2.2 shall be performed according to MSFC-HDBK-505. With TRW approval these tests may be performed prior to formal verification.

4.3.3.2 Redundancy Tests

All redundant elements and paths shall be tested to verify that redundant elements perform according to the requirements defined in Section 3.2.3.3.

4.3.3.3 Interface Verification

Thermal, structural, electrical and optical interfaces between the AC, SLS, and PEA and the HRMA and/or OBA shall be verified as specified in Table X to assure compliance with Sections 3.2.2.4 and 3.2.2.9.

4.3.4 Acceptance Verification

Acceptance verification is the process that verifies the flight hardware will perform satisfactorily at conditions less than or equal to the specified requirements. Acceptance verification of the ACA shall include Section 4.2 to verify conformance to the requirements of Sections 3.2 and 3.3. It shall also include the tests defined in Section 4.3.3.2. Acceptance verification of the ACA shall be performed prior to delivery to TRW.

4.4 Test Plan and Procedures

All qualification, protoflight and acceptance testing shall be performed according to an approved test plan and according to approved, released procedures. The acceptable performance limits in the test procedures shall include sufficient margins for expected performance degradation due to orbital environmental conditions.

4.5 Failure and Retest

If a failure occurs during a test, the failure shall be documented and testing shall be discontinued until an analysis is performed to determine if the condition merits continuing the tests or delaying the tests for a more detailed failure analysis. Failures during the verification required in Sections

4.3.3 and 4.3.4 shall be processed and controlled as specified in Paragraph 3.2.10 of PAR700-272. TRW shall be notified of such failures within 24 hours of their occurrences. The test shall be repeated after correcting the cause of failure. If the corrective action substantially affects the significance of the results of previously completed tests, such tests shall be repeated also.

5.0 PREPARATION FOR DELIVERY

5.1 General

The ACA components packaged as specified herein shall be protected from degradation by environments anticipated during shipment, handling, and storage. Unless otherwise specified in the contract, standard commercial packaging practices are acceptable provided they fulfill these requirements.

5.2 Preservation and Packaging

5.2.1 Cleaning

ACA components shall be clean and free of contaminants according to Section 3.3.1.9 prior to packaging.

5.2.2 Attaching Parts

When attaching parts, such as nuts, bolts, washers, etc., accompany a component, they shall be preserved, bagged, appropriately identified, and attached to or adjacent to the fitting for which they are intended.

5.2.3 Electrical Connectors

Connector savers and dust caps shall be used and delivered on all external electrical connectors according to Paragraph 5.7.3 of PAR700-272. Prior to delivery to TRW, all ACA socket contacts shall be tested according to Paragraphs 5.7.4 and 5.7.5 of PAR700-272.

5.2.4 Critical Surfaces

External machined surfaces and mounting surfaces of the ACA components shall be protected with protective pads. Materials used for pads shall not cause component deterioration.

5.2.5 Wrapping

Wrapping or bagging for ACA components shall be clean (level 100 A) aclar film and shall conform to Paragraph 3.4.1 of D17393 (TRW SE28).

5.2.6 Cushioning

ACA components shall be cushioned using a suitable resilient foam cushioning material such as polyethylene. Polyurethane or polystyrene foams are acceptable only if bagged in acceptable polyethylene.

5.3 Packing

Each component shall be packed in a suitable shipping container designed for one component only. The shipping containers shall provide protection for the ACA components against corrosion, deterioration, contamination, and damage during shipment from the source of supply to the receiving activity. Containers shall comply with Paragraphs 3.4.2 and 3.4.3 of D17393 (TRW SE28) and with applicable tariffs and regulations for particular modes of transportation when so shipped.

5.4 Marking for Shipment

Each unit container and shipping container shall be marked in accordance with PAR700-272 on each side, top and bottom with the following:

(a) Item Nomenclature
(b) TRW part number and serial number
(c) FRAGILE - HANDLE WITH CARE
(d) ITEMS FOR SPACE FLIGHT USE
(e) Manufacturer's name
(f) Manufacturer's CAGE code number
(g) Prime contract number: NAS8-37710
(h) Manufacturer's part number
(i) Equipment specification no.: EQ7-278
(j) Program name: AXAF-I
(k) Configured end item no.: L70701P

All marking for space flight items shall be blue in color. In addition, one NASA Critical Item Label shall be affixed to each exterior container. This label may be obtained from MSFC in the following sizes:

(a) NASA Form 1368 - 4 by 8 inches
(b) NASA Form 1368A - 3 by 6 inches
(c) NASA Form 1368B - 2 by 3-1/2 inches

5.5 Documentation

All required reliability and test documentation such as test reports, certifications, shipping invoices, etc., shall be either packed in the item container or attached to the exterior surface of the shipping container. Attachment shall be in such a manner as to preclude the loss of this data during handling and shipment by common carrier.

6.0 NOTES

6.1 Indication of a Revision or Change

The margins of this specification are marked with the appropriate symbol where modifications of the previous issue have been made.

6.2 Acronyms and Abbreviations

AC	Aspect Camera
ACA	Aspect Camera Assembly
ASC	AXAF Science Center
AXAF-I	Advanced X-ray Astrophysics Facility - Imaging
CCD	Charge Coupled Device
CCDM	Communications, Command, and Data Management
EPS	Electrical Power Subsystem
FOV	Field-of-View
FPA	Focal Plane Assembly
FTM	Fiducial Transfer Mirror
FTP	Fiducial Transfer Periscope
HRMA	High Resolution Mirror Assembly
IRU	Inertial Reference Unit
IU	Interface Unit
LOS	Line-of-Sight
LSB	Least Significant Bit
MSB	Most Significant Bit
OBA	Optical Bench Assembly
OBC	On-Board Computer
OTA	Optical Telescope Assembly
PCAD	Pointing Control and Attitude Determination
PEA	Processing Electronics Assembly
RCTU	Remote Command and Telemetry Unit
SI	Science Instrument
SLS	Stray Light Shade
TBR	To Be Resolved
TS	Telescope System