36-01501.01

AXAF-I CCD Imaging Spectrometer (ACIS)

Verification Assessment Report -Power and Thermal-Control Structure- -Reliability Analysis Report-

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Submitted to:
Massachusetts Institute of Technology
Center for Space Research
77 Massachusetts Avenue
Cambridge, MA 02139

Submitted By:
Lockheed Martin Astronautics
P.O. Box 179
Denver, CO 80201

Prepared By:

Donald C. Larson
Verification Engineering
Lockheed Martin Astronautics

Approvals:

Larry G. Campbell
Systems Engineering Lead
Lockheed Martin Astronautics

Lloyd P. Oldham
Program Manager
Lockheed Martin Astronautics

CHANGE/REVISION RECORD

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1. INTRODUCTION

1.1 Scope

This document provides a collection of information which results from the implementation of the ACIS Verification Plan, 36-01203. It is intended to show that the delivered instrument meets a specific set of requirements from the ACIS Power and Thermal-Control Structure (PTS) Specification, ACIS-36-02101.

In particular, this report provides the analytical data to support the verification of specific PTS Specification requirements. These requirements were assessed to be best verified by a analysis. The method selected in the verification of each specific requirement is the method which provides the assurance to the program that the requirements have been verified.

The Verification Cross Reference Matrix contained in the ACIS PTS Specification shows how each contractual requirement will be verified. The requirements documented herein have been designated to be verified by analysis and/or a combination of other verification methods.

1.2 Applicable Documents

ACIS Project Documents

36-02101	ACIS Power and Thermal-Control Structure (PTS) Specification
36-01203	ACIS Verification and Calibration Plan

2. METHODOLOGY

2.1 Requirements & Specifications

Verification methods to be used are defined in the verification matrix, compiled as an appendix to the ACIS Power and Thermal-Control Structure Specification, 36-02101.

2.2 Verification Descriptions

Summary level descriptions of each verification activity are located in the ACIS Verification Plan, 36-01203 and the ACIS Power and Thermal-Control Structure Specification, 36-02101. The specific definitions for this report are as follows:

2.2.1 Analysis Definition

Analysis is a method of verification, taking the form of the processing and accumulated results and conclusions, intended to provide proof that verification of a requirement(s) has been accomplished. The analytical results may be based on engineering study, compilation or interpretation of existing information, similarity to previously verified requirements, or derived from lower level examinations, tests, demonstrations, or analyses. Verification by analysis is a process used in lieu of or in addition to testing to verify compliance with specification requirements. The selected techniques may include systems engineering analysis, statistics and qualitative analysis, computer and hardware simulations, and analog modeling. Analytical techniques may be used in lieu of tests for such things as life, storage, failure analysis, safety, interchangability, and some other performance requirements which cannot be verified by test.

2.2.2 Reliability Analysis Definition

Reliability analysis assures that all hardware has sufficient life to complete the mission and meet quantitative and contractual life limit requirements. Reliability tasks will be in accordance with ACIS Product Assurance and Safety Plan, 36-01202.

3. ANALYSIS

3.1 Applicable Requirements

	Requirement Reference	Requirement

1. 3.2.3a Reliability
   The Power and Thermal-Control Structure reliability program shall be implemented in compliance with the requirements of NHB 5300.4 (1A-1).

2. 3.2.3b Reliability
   Assurance of mission reliability shall be accomplished by successful completion of protoflight test program using the environments specified in section 4.0 herein, as well as acceptable Failure Modes and Effect Analysis, Worst Case Analysis of Stress Analysis results, selection of piece parts in accordance with the provision prescribed herein, and the use of proven processes.

3. 3.2.3c Reliability
   Failures within the Power and Thermal-Control Structure shall not propagate to the AXAF-I observatory nor the High Resolution Camera (HRC) in a manner to cause loss of the AXAF-I mission.

4. 3.2.3d Reliability
   Failures within the Detector and Processor Subsystem that interface to the Power and Thermal-Control Structure shall not propagate through the Power and Thermal-Control Structure to the AXAF vehicle nor to other science instrument(s) in a manner to cause loss of the AXAF-I mission.

5. 3.2.3e Reliability
   Power and Thermal-Control Structure Electronic, Electrical and Electro-mechanical parts shall be derated in accordance with Appendix A MIL-STD-975 or in accordance with Lockheed Martin worst case analysis guidelines WC-001, Rev A whichever is most restrictive.

6. 3.3.5.1.4a Critical Components
   Critical items shall be as defined in MSFC CR-5320.9.

3.2 Analytical Discussion

The Power and Thermal-Control Structure input to the ACIS Failure Modes and Effects Analysis is provided for review and comment per contractual data requirement PA04. An example of the data provided in this analysis is attached in appendix A.

	Requirement Reference	Requirement
1.	3.2.3a	Reliability

The Power and Thermal-Control Structure reliability program shall be implemented in compliance with the requirements of NHB 5300.4 (1A-1).

DISCUSSION

The Power and Thermal-Control Structure has been designed to assure reliability in compliance with the requirements of NHB 5300.4 (1A-1), Reliability Program Requirements for Aeronautical and Space Systems Contractors. Compliance is detailed in section 3 of the Product Assurance and Safety Plan for ACIS, ACIS-36-01202, provided in compliance with Contractual Data Requirements SPA01. The implementation of NHB 5300.4 (1A-1) is reflected in the Power and Thermal-Control Structure engineering drawings provided in compliance with Contractual Data Requirements SE04. The actual implementation of the processes is reflected in the hardware build logs provided in compliance with Contractual Data Requirements CM10. The requested activity has occurred. This discussion verifies compliance with paragraph 3.2.3a of the PTS Specification, no further action is required.

2.	3.2.3b	Reliability

Assurance of mission reliability shall be accomplished by successful completion of protoflight test program using the environments specified in section 4.0 herein, as well as acceptable Failure Modes and Effect Analysis, Worst Case Analysis of Stress Analysis results, selection of piece parts in accordance with the provision prescribed herein, and the use of proven processes.

DISCUSSION

The Power and Thermal-Control Structure has been designed to assure mission reliability. The Power and Thermal-Control Structure has experienced a successful protoflight test program. The results of the testing are provided in the following reports:

#	Event Number	Event Title	Responsible Person
1	ACIS-000-77-01VR	ACIS System Thermal Vacuum Test	N. Tice
2	ACIS-000-78-01VR	ACIS EMI/EMC Test	L. Campbell
3	ACIS-110-41-10VR	Detector Housing Performance Test	N. Tice
4	ACIS-110-43-03VR	Detector Housing/Venting Subsystem Leak Test	S. Anderson
5	ACIS-110-74-01VR	Detector Housing Random Vibration Test	R. Simon
6	ACIS-110-77-01VR	Detector Housing Thermal Vacuum Test	N. Tice
7	ACIS-120-74-01VR	Venting Subsystem Random Vibration Test	R. Simon
8	ACIS-400-25-04VR	PSMC Performance Test	E. Sedivy
9	ACIS-400-74-01VR	PSMC Random Vibration Test	R. Simon
10	ACIS-500-74-01VR	Thermal Control Subsystem Acoustic Test	R. Simon
11	ACIS-500-77-01VR	Thermal Control Subsystem Thermal Balance Test	N. Tice

These reports will be provided in compliance with Contractual Data Requirements SVR04. A Failure Modes and Effects Analysis has been performed on the Power and Thermal-Control Structure and provided in compliance with Contractual Data Requirements SPA04. The results of the Failure Modes and Effects Analysis, ACIS-36-01406, substantiate that the design assures mission reliability with redundancy in most critical areas and degraded,

yet mission successful, operation in those areas not redundant. The stress analyses have been performed on the Power and Thermal-Control Structure and provided in compliance with Contractual Data Requirements SE03. All structural margins are positive for the loads specified with no concern of structural yielding or failure. A worse case analysis of all electrical circuits has been performed and piece parts selected to operate in a derated manner in accordance with Appendix A MIL-STD-975 or in accordance with Lockheed Martin worst case analysis guidelines WC-001, Rev A whichever is most restrictive. All materials, parts and processes are defined by standards, specifications and processes selected from MM 8070.2 and MSFC-HDBK-527. Selection of contractor specifications and standards over existing higher order of precedence standards, specifications, and procedures have had prior MSFC approval. The processes used are reflected in the Power and Thermal-Control Structure engineering drawings provided in compliance with Contractual Data Requirements SE04. The actual implementation of the processes is reflected in the hardware build logs provided in compliance with Contractual Data Requirements CM10.
The above actions have been performed and reported in compliance with Contractual Data Requirements listed. As such, the design and construction of the Power and Thermal-Control Structure has been done to assure the mission reliability of the Power and Thermal-Control Structure and the ACIS Instrument. This discussion verifies compliance with paragraph 3.2.3b of the PTS Specification, no further action is required.

3. 3.2.3c Reliability
Failures within the Power and Thermal-Control Structure shall not propagate to the AXAF-I observatory nor the High Resolution Camera (HRC) in a manner to cause loss of the AXAF-I mission.

DISCUSSION
Power and Thermal-Control Structure failures will not propagate to the AXAF-I observatory or the High Resolution Camera (HRC) in a manner to cause loss of the AXAF-I mission. The Power and Thermal-Control Structure structure has been tested and analyzed to the specified mission loads. The structural stress analyses have been performed on the Power and Thermal-Control Structure and provided in compliance with Contractual Data Requirements SE03. All structural margins are positive therefore no structural failure will occur. The mechanisms involved in the Power and Thermal-Control Structure are the vent valves and door mechanism. Since the mechanisms are of relatively low power and not directly connected to the observatory or HRC, failure of either of these mechanisms cannot feasibly propagate any further failure to the observatory or the HRC. The thermal design is generally passive with thermal control for the Power Supply and Mechanism Controller and the Venting subsystem maintained by the observatory, i.e., Science Integration Module. Failure of the radiator system cannot feasibly propagate any further failure to the observatory or the HRC. The electrical subsystem interfaces to the observatory only via the Power Supply and Mechanism Controller. There are no direct electrical interfaces to the HRC. The Power Supply and Mechanism Controller is adequately fused and circuit protected to preclude the propagation of a failure in the PSMC to the observatory. The circuit protection features of the Power Supply and Mechanism Controller are detailed in the engineering 849AC42000, provided in compliance with Contractual Data Requirements SE04. The actual implementation of the design is reflected in the hardware build logs provided in compliance with Contractual Data Requirements CM10. The requested activity has occurred. This discussion verifies compliance with paragraph 3.2.3c of the PTS Specification, no further action is required.

4. 3.2.3d Reliability

Failures within the Detector and Processor Subsystem that interface to the Power and Thermal-Control Structure shall not propagate through the Power and Thermal-Control Structure to the AXAF vehicle nor to other science instrument(s) in a manner to cause loss of the AXAF-I mission.

DISCUSSION

Failures within the Detector and Processor Subsystem that interface to the Power and Thermal-Control Structure failures will not propagate to the AXAF-I observatory or the High Resolution Camera (HRC) in a manner to cause loss of the AXAF-I mission. This requirement applies only to the propagation of electrical failures from the Detector and Processor Subsystem to the Power and Thermal-Control Structure. Structural and thermal failures between the DPS and the PTS cannot feasibly propagate any further failure to the observatory or the HRC. The electrical subsystem interfaces to the observatory only via the Detector Electronics Assembly and Digital Processor Assembly to the Power Supply and Mechanism Controller. There are no direct electrical interfaces to the HRC. The Power Supply and Mechanism Controller is adequately fused and circuit protected to preclude the propagate a failure in the PSMC to the observatory. The circuit protection features of the Power Supply and Mechanism Controller are detailed in the engineering 849AC42000, provided in compliance with Contractual Data Requirements SE04. The actual implementation of the design is reflected in the hardware build logs provided in compliance with Contractual Data Requirements CM10. The requested activity has occurred. This discussion verifies compliance with paragraph 3.2.3d of the PTS Specification, no further action is required.

5. 3.2.3e Reliability

Power and Thermal-Control Structure Electronic, Electrical and Electro-mechanical parts shall be derated in accordance with Appendix A MIL-STD-975 or in accordance with Lockheed Martin worst case analysis guidelines WC-001, Rev A whichever is most restrictive.

DISCUSSION

The Power and Thermal-Control Structure Electronic, Electrical and Electro-mechanical parts have been derated in accordance with Appendix A MIL-STD-975 or in accordance with Lockheed Martin worst case analysis guidelines WC-001, Rev A whichever is most restrictive. The process for selecting and incorporating the properly derated parts is detailed in numerous contractual data requirements. The Electronic, Electrical and Electro-mechanical parts have been analyzed for usage in the EEE Parts Application Analysis information provided in compliance with Contractual Data Requirements PA010 and also documented in the various circuit analyses provided in compliance with Contractual Data Requirements SE03. In performing this analysis the derating factors detailed in MIL-STD-975 or WC-001 were incorporated. The Electronic, Electrical and Electro-mechanical parts are then listed in the Approved EEE Parts List provided in compliance with Contractual Data Requirements PA02. The EEE parts are detailed in the design engineering provided in compliance with Contractual Data Requirements SE04. The actual implementation of the design is reflected in the hardware build logs provided in compliance with Contractual Data Requirements CM10.

The requested activity has occurred. This discussion verifies compliance with paragraph 3.2.3e of the PTS Specification, no further action is required.

6. 3.3.5.1.4a Critical Components
Critical items shall be as defined in MSFC CR-5320.9.

DISCUSSION
The Power and Thermal-Control Structure Critical items have been identified as defined in MSFC CR-5320.9, Payload and Experiment Failure Mode and Effects Analysis and Critical Items List Groundrules. The critical items list generated for the Power and Thermal-Control Structure components and piece parts was performed in compliance with the document specified. The Power and Thermal-Control Structure Critical Items List, ACIS-CIL-01, has been provided in compliance with Contractual Data Requirements PA05. This input is then blended with the DPS portion of the Critical items List to generate the ACIS Critical Items List, ACIS-36-1407. An example of a ACIS Critical Items List entry is provided in appendix B. The requested activity has occurred and been contractually documented. This discussion verifies compliance with paragraph 3.3.5.1.4a of the PTS Specification, no further action is required.

Appendix A

Failure Modes and Effects Analysis Example

per ACIS Failure Modes and Effects Analysis, ACIS-36-01406

FAILURE MODES AND EFFECTS ANALYSIS WORKSHEET

System: ACIS
Component: Power Supply & Mechanism Controller
Assembly: 1.3.5 I/O EMI Filter Assembly
Quantity: 1
Drawing/Schematic 849AC405001
FMEA Item Code 1.3.5
Function: Receives +28vdc directly from the spacecraft power bus, and provides conducted emissions and susceptibility filtering for the PSMC. Receives secondary voltages from the DPA and DEA power supplies and provides conducted emissions and susceptibility filtering for the DPA and DEA load circuits.

Date: 1/30/97
Revision: 04
Hazard Ref:
Effectivity:

Mission Phases
1. Prelaunch
2. Ascent
3. Deployment
4. Operations
5. Contingency/Return

A-2

ID	Failure Mode	Causes	Phase	Crit. Code	Red. Scr. A,B,C	Failure Effects (A) Item/System (B) Mission (C) Shuttle Vehicle/Crew	Remarks (A) Redundancy & Correct. Action (B) Detection Method & Reaction (C) Software Response
1	Loss of +/- 6V, +/- 15.5V, +24V, or +28V power outputs	•EMI cavity failure. •EMI filter capacitors short to ground. •Output connectors short to ground or open. •Internal cable assemblies fail open.	4	2PR	Pass N/A Pass	(A) Unable to supply power to the DEA. Loss of science data due to loss of DEA operation. (B) Loss of ACIS Mission. (C) No Effect.	(A) Switch to PSMC redundant side. Commands received from ground switch PSMC from Side A to Side B. Fail effect time: immediate. (B) Loss of DEA input power detected by ground crew via telemetry. Reaction: hours/days. (C) N/A.

Appendix B

Critical Items List Example

per ACIS Critical Items List, ACIS-36-01407

CRITICAL ITEMS LIST

SYSTEM:	ACIS	**Crit. Category**	2PR
COMPONENT:	PSMC	**Part Name:**	N/A
ASSEMBLY:	I/O EMI Filter Assy	**Part Number:**	849AC405001
FMEA ITEM CODE:	1.3.5	**Phase:**	4
REV. NO. & DATE:	03 - 2/14/97	**Quantity:**	1
FUNCTION:	Receives +28 Vdc directly from the spacecraft power bus, and provides conducted emissions and susceptibility filtering for the PSMC. Receives secondary voltages from the DPA and DEA power supplies and provides conducted emissions and susceptibility filtering for the DPA and DEA load circuits.		

FAILURE MODE AND EFFECT:
Loss of +/- 6V, +/- 15.5V, +24V, or +28V power outputs.
Unable to supply power to the DEA. Loss of science data due to loss of DEA operation. Loss of AXAF mission.

FAILURE CAUSE(S):
EMI cavity failure.
EMI filter capacitors short to ground.
Output connectors short to ground or open.
Internal cable assemblies fail open.

REDUNDANCY SCREENS: (Pass/Fail/N/A)	***SCREEN A***	Pass
	SCREEN B	N/A
	SCREEN C	Fail

RATIONALE FOR RETENTION:

Design:
Redundant circuits within PSMC.

Test:
Board and PSMC level testing.
Thermal test of PSMC.
Thermal Vac Testing on AXAF

Inspection:
Board and PSMC level inspection.

Failure History/Related Experience:
No failure history or trends identified.

Operational use:
ACIS undergoes no predeployment checkout in the Shuttle Bay prior to deployment.
Reference TRW Document # DPD 692OP16 Orbital Verification Activity Requirements.