RBSP EFW AXB

Specification

RBSP EFW_AXB_001

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Revision C

Signature Page

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Change Record

Date	Revision	Description
6/18/2008	-	Draft
7/11/2008	1	Added DWC suggestions (IRD, DDD, etc.)
8/28/2008	A	IRD Updates, Packaging Updates, Released for iPDR
9/29/2009	B	Removed Ground Strap, Requirements, Epoxy, Thread Locking Updated, Released for iCDR.
10/28/2009	C	Synchronized IRD Requirements to text.

0. APPLICABLE DOCUMENTATION

The following documents are applicable to the extent specified herein. In the event of a conflict, the requirements of this document shall govern.

7417_9096 RBSP_EFW_PA_004	APL Flow Down Matrix
7417_9018	RBSP EMECP - Electromagnetic Environment Control Plan
RBSP_AXB_MEC_001	AXB Assembly
RBSP_AXB_ICD_001	Interface Control Drawing
RBSP_EFW_AXB_002W	RBSP EFW AXB Wiring Schematic
RBSP_EFW_SYS_001	RBSP EFW Instrument Requirements Document
RBSP_EFW_PA_001B	RBSP EFW Performance Assurance Implementation Plan
RBSP_EFW_PA_005A	RBSP EFW Contamination Control Plan
RBSP_EFW_PA_007A	RBSP EFW Bakeout Plan
RBSP_EFW_TE_001	RBSP EFW Verification, Validation, Test, and Calibration Plan
SSL_CCP_010	Clean Room Gowning Procedure
SSL_CCP_011	Clean Room Guidelines
SSL_CCP_020	Mechanical Part Cleaning Procedure
THM_SPB_MEC_001	SPB Assembly

1. Introduction

The RBSP EFW Axial Boom (AXB) follows a long line of deployable axial antennas now flying on a number of spacecraft. Many of the modules in RBSP EFW are unchanged from those who have logged more than 60 years of on-orbit operation. Specifically, the RBSP AXB is an adaptation of the design of the THEMIS AXB with addition of new locking features for the deployment assist device (DAD) and a motor drive mechanism for in-flight length control during deployment.

This document is intended as a written appendage to the IRD maintaining important details not recorded in the IRD. Specifications will be listed by type (mechanical, electrical, etc.) and discussed as necessary.

2. Designation

Two identical AXB in Tube Assemblies will be produced; one each for Spacecraft A and B [EFW-21, -22, -212]. These assemblies will consist of a Tube Assembly (which mounts to the spacecraft structure) and two (2) identical AXB Assemblies. The AXBS are designated as follows for the EFW Instrument:

Boom 5 is the AXB which is sunward.
Boom 6 is the AXB which is anti-sunward.

3. Mechanical

3.1 ICD Compliance:

The AXB in Tube Assemblies will comply with the mechanical Interface Control Drawing, RBSP-AXB-ICD-001 [EFW-23, -54, -90].

3.2 Materials and Construction:

The AXB in Tube Assemblies will be built with SSL standard materials and practices [EFW-1, -2, -7, -8, -202, -12, -24, -103, -106, -107, -108, -137, -211].

3.3 Length:

Designed as up to 14 meters from center of sphere to center of sphere [EFW-209, -51, -52]. Final length will be determined on orbit by an integral motor driven deployment device. Required accuracy of final deploy length is to be within 1 cm; this accuracy demands a minimum of 16 turns counter clicks per turn of the wire spool. The Flight Spool will have a total of 24 turns counter clicks per turn.

Length per click (on to on) is as follows:

	l/click (in)	l/click (cm)	L at end of row (m)
1st row wrap	0.21	0.52	6.66
2nd row wrap	0.22	0.57	5.29
3rd row wrap	0.24	0.61	3.65
4th row wrap	0.26	0.66	1.89

3.4 Packaging:

See IRD and RBSP-AXB-ICD-001. Final packaging is a M55J Graphite Epoxy tube of 5.8" ID. Spacing between decks is 43.5". Aluminum flanges will be bonded to the ends of the Tube to interface with the deck. Due to CTE mismatch between the Tube and the SC, a flexure is incorporated into the –Z mount. Current design specifications show a need for 0.054" at 52C dT. Mounting and flatness tolerances are as shown in the ICD, RBSP-AXB-ICD-001.

3.5 Motor Drive Mechanism

This unit is adapted from the THEMIS Spin Plane Booms (SPBs), see THM-SPB-MEC-001. All details of the motor housing itself are similar save the orientation of the two screws on the outside cavity to hold the cap with the electrodes passing through. These two screw holes had to be clocked 90 degrees from the THEMIS SPB design. Identical mu-metal shielding is required.

The gear ratio has been changed for the RBSP EFW to 1000:1 from 3000:1. This creates a correspondingly smaller gear housing and therefore motor housing overall. Note: It is expected that these motors overrun slightly. It is also expected that these motors cannot be back driven due to the high gear ratio; ETU testing confirmed this.

3.6 Blends and Fillets

Many of the blends and fillets shown in the SolidWorks model to protect wires should be added by hand after machining for simplicity. These blends and fillets are called out on manufacturing drawings or assembly procedures, as appropriate.

3.7 Harness Mechanical Termination

3.7.1 Tip Piece Bonding

As the harness enters the tip piece, it terminates and bonds to the tip piece as follows:

1) The metallic braid and Tefzel overwrap ends as the harness enters the Wire Ferrule (RBSP-AXB-MEC-172).

2) The Kevlar braid continues into the Wire Ferrule and is bonded with epoxy.
3) Where the Wire Ferrule opens into the larger cavity, the Kevlar braid ends.
4) The wires are left to attach to the connector at the hinge with sufficient service loop to remove the connector from the Wire Ferrule if necessary yet small enough service loop that it fits within the Wire Ferrule.

3.7.2 Spool Bonding

The harness will be deployed from the spool at one end; the other end will go into the center of the spool where it will terminate in the following way:

1) The metallic braid and Tefzel overwrap will end as it enters the Spool (RBSP-AXB-MEC-522).
2) Within the Spool, the wire will wrap around the Kevlar Terminator (RBSP-AXB-MEC-524) about ¼ turn and be tied off to the 1/16” diameter pin.
3) The wires will then be exposed and soldered to the leads of the AirFlyte slipring to leave the Spool.

3.8 DAD Spring

The DAD Spring is designed from the NEWSTAR DAD springs using the spreadsheet “NuStar Telescopic SPRING DESIGN.xls”. Final parameters are as follows:

Material: 302 SS
Wire Diameter: 0.023 inch
OD: 0.276 inch
# of Active Coils: 200
Free Height: 24.05 inches
Solid Height: 4.65 inches
Stowed Height: 5.570 inches
Force at Stowed Height: 2.17 pounds
Deployed Height: 10.508 inches
Force at Deployed Height: 1.59 pounds

3.9 Fastener Locking Features

Every fastener is required to have redundant locking features. For this instrument, the following locking features will both be employed for every fastener:

1) Proper tightening of all fasteners to appropriate torque levels as calculated using the spreadsheet “Bolt Torque Calculator.xls” as developed by Dr. Pankow, SSL,
2) and Spiralock Taps or Inserts as appropriate.

There are machined threads at larger diameters than the standard fasteners. These will utilize redundant locking features that are determined by the location and application. A list of these threads and their locking features is below.

1) Hinge Nut, proper torque, stake threads at final installation to Spacecraft,
2) Hinge Connector Retainer, proper torque, stake threads,
3) Whip Nut, proper torque, stake after F1 environments,
4) Preamp Post Nut, proper torque, stake threads.

3.10 Glue Joints

3.10.1 Whip

The Whip glue joints should be made with Hysol 9309NA.

3.10.2 DAD

The DAD glue joints should be made with Hysol 9309NA.

3.10.3 Stacer Tip Piece

The Stacer Tip Piece glue joints should be made with Hysol 9309NA.

3.10.4 Omnetics Connectors

The Omnetics Connectors should be bonded with Uralane/Arathane 5753 Staking Compound.

3.11 Radiation Environment

The Radiation environment imposed by the mission requires all parts to withstand radiation doses of 10 Mrad [EFW-1, -6, -7, -8]. Standard mechanical part materials will withstand this environment. However, coatings and finishes have been screened for suitability, as has the harness.

4. Electrical

4.1 Harnessing:

The AXB Assemblies will be harnessed with connectors to provide functionality and interface to the IDPU according to standard SSL processes and procedures [EFW-56, -61, -65, -66, -68, -100, -101].

4.2 Conductivity:

There will be no isolated conductors and exposed isolators will be minimized [EFW-133, -135]. Exposed isolators will be approved on a case by case basis.

MicroLube (Electro-less Nickel Plating with Teflon Impregnate) will be tested on the prototype unit to provide both lubrication and a conductive coating on moving parts. Plating must have at least 10% phosphorous content to be sufficiently non-magnetic.

The AirFlyte slipring housing and each end of the shaft must be grounded.

4.3 Isolation:

Major subsystems of the AXB will be isolated from one another. Each subassembly will have the ability to be either grounded or driven to a specific potential. Wire attach points must be provided.

Isolated subassemblies are as follows: 1) DAD, motor housing and overall package, 2) stacer, 3) hinge assembly (“guard” on THEMIS), 4) whip (“usher” on THEMIS), 5) preamp (PA) board, and 6) sphere.

Hard Black Anodize coating is considered sufficient isolation between the rollers of the Roller Nozzles and the stacer so long as the thickness is sufficient.

4.4 Switches

Each AXB will have a total of three (3) sense switches to show: whip deployment, stacer motion from stowed configuration, and turns of the cable spool.

Each Frangibolt will have two (2) switches (one per power service) to cut off power once deployment has occurred.

The Motor will have one (1) end of wire (EOW) switch to cut off power once the wire is at its end of travel.

All switches will be Honeywell 1HM19.

4.5 Heaters:

No heaters are required for the AXB in Tube Assemblies [EFW-69].

4.6 Motors:

One Globe Motor, part number 43A153-1 per M43M371, will be used to deploy the stacer harness [EFW-74].

4.7 Frangibolts:

One Frangibolt, part number FC2-16-31SR2, will be used to actuate the Caging Mechanism and one to release the Stacer in the AXB in Tube Assemblies [EFW-72, -73].

4.8 Grounding

There is a metal to metal contact of each AXB unit to the spacecraft. No ground strap is required.

4.9 Dialectric Withstanding Voltage

A 1000V Dielectric Withstanding Voltage test end-to-end (prior to connecting the Preamp) will be run after internal harness installation since some parts are not rated to 1000V and are not easy to test at the component level (notably the Omnetics connectors). The Epoxy for bonding the Omnetics connectors was chosen to meet this requirement.

4.10 Enable Plug:

An enable plug will be included which will provide both a safety against accidental ground deployment and also an interface for GSE and ground calibration [EFW-92]. Flight Enable pugs will be Alodined. Ground or Science Enable Plugs will be Red Anodized.

5. Contamination Control

The hardware will be built with methods that control and verify contamination as required by RBSP_EFW_PA_005A [EFW-132]. Standard SSL procedures for cleaning and cleanroom activities will be used.

6. Testing

6.1 Environmental Test Plan

The AXB Assemblies and the Tube Assemblies will experience an environmental test sequence as detailed in the EDTRD and the RBSP EFW Verification, Validation, Test, and Calibration Plan [EFW-136].

6.2 Thermal Vacuum Testing

A thermal vacuum test will be preformed to demonstrate survival and operational test extremes are met [EFW-201, -77, -80].

6.3 Bakeout

A bakeout of the hardware shall be performed as required by RBSP_EFW_PA_007A.

6.4 Runout Testing

A runout test will be preformed to demonstrate alignment requirements are met [EFW-202, -9, -10, -11, -203, -54a].

6.5 Frangibolt Logs

The frangibolts have an actuation log that captures firing time, reset length, voltage and current settings, etc.
Initial review of the THEMIS procedures indicate actuation times on the order of 2 minutes. However, early data shows actuation times as low as 5 seconds. Data from the logs will be used to provide an estimate of timing by environment, but additional data is required to make such an estimate accurate.

6.6 Science Calibration

A Science Calibration will be preformed to calibrate the AXB Assemblies [EFW-200].

7. RBSP_EFW_SYS_001 Instrument Requirements Document (IRD) Flowdown

Below are the lines from the IRD that relate specifically to the AXB Mechanical design (From RBSP_EFW_SYS_001, Rev. J).

ID	Req. Title	Prio rity	Requirement Body or Section Heading
			3 Functional Requirements
			3.1 Functional, performance and general design requirments
EFW-1	**Instrument Design life**	shall	be designed for a total lifetime duration of 2 years plus 60 days.
EFW-200	**Instrument Calibration**	shall	be calibrated prior to launch, and be designed to accommodate additional in-flight calibration
EFW-6	**Instrument Orbit Inclination Operability**	shall	be capable of operating in an orbit with an inclination of 10° ± 0.25°.
EFW-7	**Instrument Orbit Perigee Operability**	shall	be capable of operating in an orbit where perigee altitude is between 500 km and 675 km (TBR).
EFW-8	**Instrument Orbit Apogee Operability**	shall	be capable of operating in an orbit where apogee altitude is between 30,050 km and 31,250 km (TBR).
EFW-201	**Instrument Accommodation of Observatory Sun Off-Point Angle (Component)**	shall	shall be capable of collecting required science measurements under the condition where the off-pointing angle between the spin axis of each observatory and the Sun-Earth line during nominal operations does not exceed 25 degrees North or South of the ecliptic plane, or 25 degrees East or West in the ecliptic plane, where "north" and "south" are with respect to an ecliptic coordinate system.
EFW-202	**Instrument Accommodation of Observatory Sun Off-Point Angle (Composite)**	shall	be capable of collecting required science measurements under the condition where the total off-pointing angle between the spin axis of each observatory and the Sun-Earth line during nominal operations is greater than 15 degrees, and does not exceed 27 degrees.
EFW-9	**Instrument Accommodation of Observatory Operational Spin Rate Range**	shall	be capable of operating nominally within an observatory spin rate range of no less than 4 rpm and no more than 6 rpm.
EFW-10	**Instrument Accommodation of Observatory Selected Operational Spin Rate**	shall	be capable of collecting required science measurements at a specific, optimal spin rate selected for both observatories that is within the specified allowable range
EFW-11	**Instrument Accommodation of Observatory Selected Spin Rate Stability**	shall	be capable of collecting required science measurements at an observatory spin rate that is maintained to within +/- 0.25 rpm of the in-flight selected value, except during maneuvers.

EFW-203	**Instrument Accommodation of Observatory Commissioning Spin Rate Range**	shall	be capable of accommodating an observatory spin rate during commissioning period activities within a range between 3 RPM (TBR) and 15 RPM (TBR).
EFW-12	**Instrument Accommodation of Unattended Mission Operations**	shall	be designed to accommodate periods of unattended mission operations (unstaffed MOC) during the operational phase of the mission of up to TBD hours
EFW-21	**EFW Instrument Complement**	shall	consist of four orthogonally oriented, boom-mounted spin-plane boom-mounted sensors, an Electronics Box, and two axial boom mounted sensors with harness as defined in the Spacecraft to EFW ICD.
EFW-22	**Functionally Identical EFW Instrument Suites**	shall	be functionally identical.
EFW-23	**EFW - Spacecraft ICD Compliance**	shall	comply with the EFW-to-Spacecraft interface control documents (ICDs).
EFW-24	**EFW Instrument Availability**	shall	be designed to be available for the collection of its required measurements at least 99% of the time during the operational phase of the mission
EFW-209	**EFW Spin Axis Measurement Sensitivity Validty**	shall	meet Spin Axis measurement sensitivity requirements outside time periods defined as follows: the interval where the aft axial boom is shadowed by the spacecraft or solar panels, and 25 seconds after the end of such periods.
EFW-51	**Measure Spin Axis DC Electric Field (Survey)**	shall	measure axial electric field components (survey), as follows: -- frequency range: DC to 15Hz; -- magnitude range: 2 mV/m - 500 mV/m; -- cadence: 32 vectors/second; -- sensitivity: 4 mV/m or 20% for R > 3.5 Re, 6 mV/m or 20% for 3.5 Re > R > 2.5 Re, 12 mV/m or 20% for R < 2.5 Re.
EFW-52	**Measure Spin Axis DC Electric Field (Burst)**	shall	measure axial electric field components (burst), as follows: -- frequency range: DC to 256 Hz; -- magnitude range: 0.4 - 500 mV/m; -- cadence: 512 samples per second; -- sensitivity: 1 mV/m or 10% @ 50 Hz (TBR).
			Required Components to Achieve Above
EFW-54	**EFW Axial E-Field Booms**	shall	be capable of deploying 7 meters with an E-Field sensor preamp at the end capable of measuring E-Fields to 400 kHz
EFW-54a	**EFW Axial E-Field Booms**	shall	Deploy the AXB sensors within +/- 1 degree of the AXB deployment system axis

EFW-56	**EFW Harnessing**	shall	connect the SPB, AXB, IDPU, EMFISIS/MAG and EMFISIS/SCM units together as detailed in the ICDs
EFW-61	**EFW Power Control**	shall	contain circuitry to open SPB and AXB doors and deploy sensors
			3.2 Power allocations and related requirements
EFW-65	**EFW Main Power Max Voltage**	shall	tolerate without damage a maximum input voltage of 40V indefinitely as defined in the ICD
EFW-66	**EFW Main Power Turn Off**	shall	tolerate without damage having power removed without notice as defined in the ICD
EFW-68	**EFW AXB Deployment Power**	shall	not exceed 4.0 Amps from the EFW AXB Deployment Service
EFW-69	**EFW Survival Heaters**	shall	accommodate survival heaters up to 1/2 nominal power at 22V bus voltage, or approximately 113 Ohms if necessary.
			3.3 Performance budget sub-allocations with respect to system budgets
EFW-72	**EFW AXB Whip Release Power**	shall	not exceed 2.0 Amps at 28V
EFW-73	**EFW AXB Stacer Release Power**	shall	not exceed 2.0 Amps at 28V
EFW-74	**EFW AXB Motor Power**	shall	not exceed 0.2 Amps at 28V (1.5A startup)
			3.4 Operational requirements
EFW-77	**EFW AXB Operational Temp Range**	shall	perform as designed from -25 to +55C (TBR)
EFW-80	**EFW AXB Survival Temp Range**	shall	survive without damage from -30 to +60C (TBR)
			3.6 Interfaces to the spacecraft bus
EFW-90	**EFW AXB ICD Compliance**	shall	comply with the requirements and constraints imposed by all relevant instrument-to-spacecraft interface control documents (ICDs).
			3.8 System test Interfaces
EFW-92	**AXB Signal Test Input**	shall	provide a connector for test input to the sensor accessible when the top and bottom of the spacecraft are accessible.
			3.10 Fault detection and correction considerations/requirements
EFW-100	**EFW AXB Deployment Enable**	shall	not deploy AXB booms or fire AXB actuators without the AXB and Main power ON.
			3.11 Redundancy description
EFW-101	**EFW Boom Pair Redundancy**	shall	have separate supplies for each preamp boom axis

			3.12 Mass allocation
EFW-103	**EFW Total Mass**	shall	The EFW shall not exceed the total allocated mass budget of 31.62kg (or as allocated in RBSP System Mass Budget).
EFW-106	**EFW AXB Mass**	shall	not exceed 3.40 kg
EFW-107	**EFW AXB Tube Mass**	shall	not exceed 1.29 kg
EFW-108	**EFW Harness Mass**	shall	not exceed 4.06kg
			3.15 Contamination control requirements
EFW-132	**Instrument Compliance with Contamination Control Plan**	shall	comply with the requirements and constraints imposed by the RBSP Observatory Contamination Control Plan, APL document no. 7417-9011
EFW-133	**Instrument Compliance with EM Environment Control Plan**	shall	comply with the requirements and constraints imposed by the RBSP Electromagnetic Environment Control Plan, APL document no. 7417-9018.
EFW-135	**EFW ESC Control**	shall	comply with the UCB Electrostatic Cleanliness (ESC) Plan
EFW-136	**Instrument Compliance with Environmental Design and Test Requirements Document**	shall	comply with the requirements and constraints imposed by the RBSP Environmental Design and Test Requirements Document, APL document no. 7417-9019.
EFW-137	**EFW Quality Assurance**	shall	comply with the RBSP Performance Assurance Implementation Plan, as modified by the Compliance Matrix
EFW-211	**Instrument Range Safety**	shall	comply with all relevant requirements and constraints imposed by AFSPC 91-710, Range Safety User Requirements Manual.
EFW-212	**Observator Naming Convention**	shall	use an observatory naming convention, as follows: -- Observatory A is the top observatory in the stacked configuration for launch; -- Observatory B is the bottom observatory in the stacked configuration for launch.