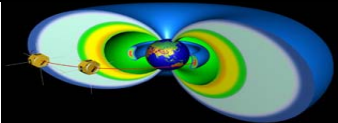


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TITLE: SPB Specification		

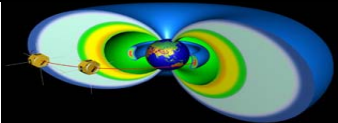
**RBSP Electric Fields and Waves (EFW)
Spin Plane Boom (SPB)
Specification**

**Revision A
October 14, 2009**

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Space Sciences Lab University of California, Berkeley	PROCEDURE	 Radiation Belt Storm Probe
TITLE: SPB Specification		RBSP-EFW-SPB-001 Specification-GD.doc Rev. A

Document Revision Record

Rev.	Date	Description of Change	Approved By
-		Draft	-
A	10/14/09	EFW Requirements, Door Release, Ref.	GD

Distribution List

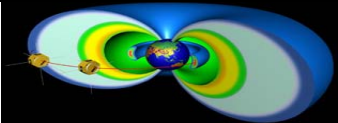
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TBDs

Identifier	Description

Reference Documents

Ref	Doc Number	Title
[1]	RBSP_EFW_SYS_004	Power
[2]	RBSP_EFW_SPB_002	Wiring Schematic
[3]	APL 7417-9018	EMECP (Electromagnetic Environment Control Plan)
[4]	RBSP_EFW_SYS_001	EFW Requirements Matrix
[5]	RBSP_EFW_SYS_003	Mass
[6]	APL 7417-9019	EDTRD (Environmental Design and Test Requirement Document)

Space Sciences Lab University of California, Berkeley	PROCEDURE	 Radiation Belt Storm Probe
TITLE: SPB Specification		RBSP-EFW-SPB-001 Specification-GD.doc Rev. A

1. Overview

The RBSP EFW Spin Plane Boom (SPB) deploy the Electric Field Instrument spherical sensors in the spin plane. The SPB cages the sphere and preamp prior to flight to protect the DAG-213 surfaces, and meters out cable for deployment length indication on orbit. All SPB's are built to the same specification and dimensions, regardless of final deployed length or location on spacecraft. Primary EFW requirements can be found in ref [4]. Those related to the SPB are included in Table 1.1:

ID	Req. Title	Subject	Priority	Requirement Body or Section Heading
EFW-9	Instrument Accommodation of Observatory Operational Spin Rate Range	Each EFW SPB	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	Each EFW SPB	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	Each EFW SPB	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-22	Functionally Identical EFW Instrument Suites	Each EFW SPB	shall	be functionally identical.
EFW-46	Measure Spin Plane DC Electric Field (Survey)	Each EFW SPB	shall	measure an electric field component perpendicular to the observatory spin axis (survey), as follows: -- frequency range: DC to 15 Hz; -- magnitude range: 0 to 500 mV/m, at geocentric distances greater than 2.5 Re; -- cadence: 32 vectors/second; -- sensitivity: 0.3 mV/m or 10% for R > 3.5 Re, 3.0 mV/m for 2.5 Re < R < 3.5 Re

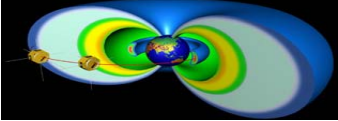
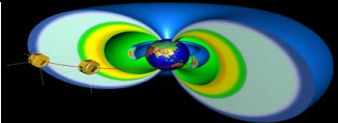
Space Sciences Lab University of California, Berkeley	PROCEDURE	 Radiation Belt Storm Probe
TITLE: SPB Specification		RBSP-EFW-SPB-001 Specification- GD.doc Rev. A

Table 1.1 Primary SPB requirements from ref [4].

Space Sciences Lab University of California, Berkeley	PROCEDURE	 Radiation Belt Storm Probe
TITLE: SPB Specification		RBSP-EFW-SPB-001 Specification-GD.doc Rev. A

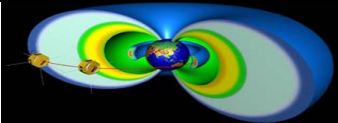
EFW-53	EFW Spin Plane E-Field Booms	Each EFW SPB	shall	be capable of deploying 50 meters of wire with an E-Field sensor preamp at the end capable of measuring E-Fields to 400 kHz
EFW-67	EFW SPB Deployment Power	Each EFW SPB	shall	not exceed 2.0 Amps from the EFW SPB Deployment Service
EFW-70	EFW SPB Door Power	Each EFW SPB	shall	not exceed 2.0 Amps at 28V
EFW-71	EFW SPB Motor Power	Each EFW SPB	shall	not exceed 0.2 Amps at 28V
EFW-79	EFW SPB Survival Temp Range	The EFW SPB	shall	survive without damage from -30 to +60C
EFW-89	EFW SPB ICD Compliance	The EFW SPB	shall	comply with the requirements and constraints imposed by all relevant instrument-to-spacecraft interface control documents (ICDs).
EFW-91	SPB Signal Test Input	Each EFW SPB	shall	provide a connector for test input to the sensor accessible during all integration phases.
EFW-105	EFW SPB Mass	The EFW SPB	shall	not exceed 2.42 kg
EFW-203	Instrument Accommodation of Observatory Commissioning Spin Rate Range	Each EFW SPB	shall	be capable of accommodating an observatory spin rate during commissioning period activities within a range between 3 RPM (TBR) and 15 RPM (TBR).

Table 1.1(cont) Primary SPB requirements from ref [4].

2. SPB Electrical Requirements

2.1 SPB Power

The SPB requires power to P5 Pin Puller to open the snout doors, and to the motor to deploy the sensor cable. Table 2.1 shows the nominal voltage and currents from previous test deployments. Electrical components (sliprings, connectors, conductors, etc) for science lines (V_{out} , V_{bias} , V_{shield} , V^+ , V^- , V_{usher} , V_{guard} , V_{braid}) must have a $\pm 250VDC$ rating from line-to-line and line-to-ground.

Space Sciences Lab University of California, Berkeley	PROCEDURE	 Radiation Belt Storm Probe
TITLE: SPB Specification		RBSP-EFW-SPB-001 Specification-GD.doc Rev. A

Parameter	Nominal Voltage (V)	Current (A)	Inrush current (A)	Inrush duration (ms)	Max run time (s)
Deploy motor	28	0.1	1.5	25	n/a
Pin Puller circuit	28	1.5	n/a	n/a	0.5

Table 2.1 Nominal SPB voltage and currents

2.2 SPB Sensing and Monitoring

The SPB shall have a AC Test line for the ability to apply a signal to the sensor for testing in the stowed configuration. This test signal will be available from the BEB through the EFW harness and from an external source through the SPB enable plug.

The SPB cable will be metered during deployment by counting turns of the metering wheel. A four-lobed cam on the metering wheel actuates a microswitch every 4.5cm of cable deployed.

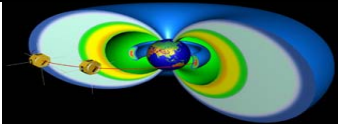
A cable overtension microswitch between the spool and metering wheel will secure power to the SPB motor in the event of an over-tension condition in the SPB cable. This condition can occur if the cable becomes nested on the spool or if the cable has reached full deployment length.

Each SPB door shall have a door-open microswitch to indicate that the snout door is fully open, permitting unobstructed deployment of sphere sensor and preamplifier enclosure.

The P5 Pin Puller has a built-in switch that secures power to the Pin Puller when it has actuated into the fired position. This protects the Pin Puller from over-heating and losing its metal memory.

2.3 Connectors

The SPB shall have one 15-pin connector for sciences signals and one 9-pin connector for actuation power and sensing (Fig 2.3.1). The EFW harness shall mate to both these connectors in a location internally accessible to the spacecraft. SPB internal wiring will shield the science from the engineering wires.

Space Sciences Lab University of California, Berkeley	PROCEDURE	 Radiation Belt Storm Probe
TITLE: SPB Specification		RBSP-EFW-SPB-001 Specification-GD.doc Rev. A

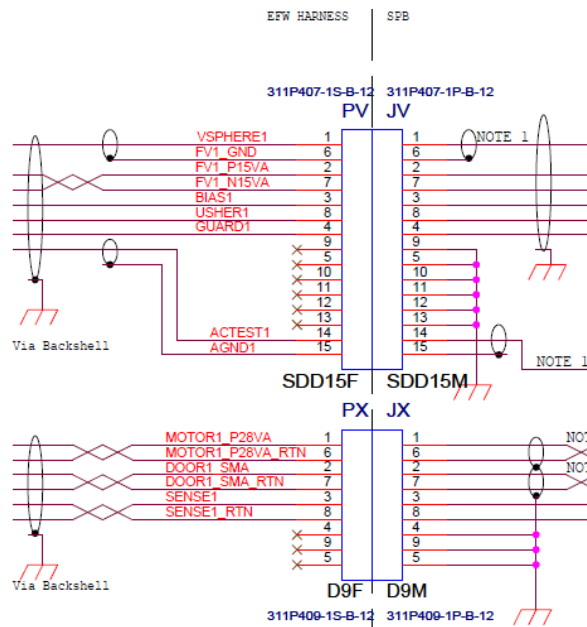
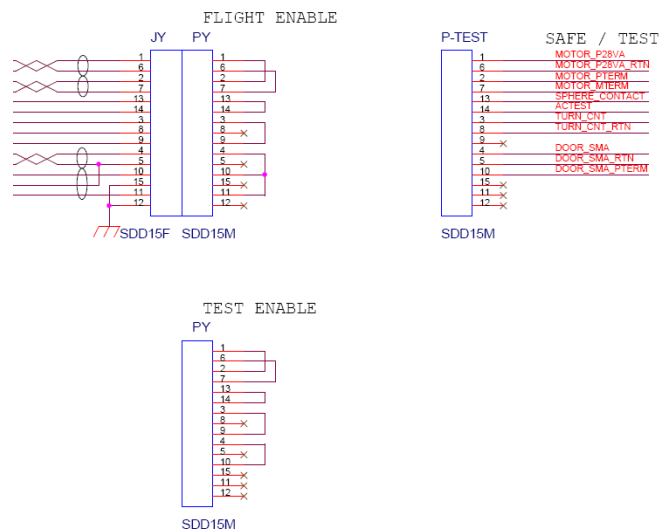


Figure 2.3.1 SPB to EFW harness connectors

The SPB flight enable plug will mate with a 15-pin connector on the front of the SPB, mounted in a location externally accessible to the spacecraft (Fig 2.3.2). Using a P-test connection, AC test signals can be injected to the sphere sensor through the enable connector, as well as test loads for the SMA door-opening circuit and deploy motor. A test enable plug is employed during testing to prevent inadvertent firing of the SPB door mechanism or running the SPB deploy motor.



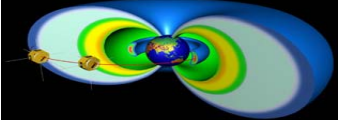
Space Sciences Lab University of California, Berkeley	PROCEDURE	 Radiation Belt Storm Probe RBSP-EFW-SPB-001 Specification-GD.doc Rev. A
TITLE: SPB Specification		

Figure 2.3.2 SPB enable connector and configurations

2.4 Deployed Cable Length

The SPB will be capable of deploying the sensors to a length of 100 meters tip-to-tip in a single axis. This is based on providing an accurate DC electric field measurement, and formulated from experience on previous spacecraft electric field measurements.

2.5 Composite Cable

A new composite cable design will be incorporated that will adhere to the following guidelines:

1. Insulation material to be made of 0.002" thick Kapton, providing greater radiation resistance than Teflon insulation.
2. The core is comprised of seven identical AWG 36 (7/44) conductors .
3. Tensile strength shall be at least 150lbf.
4. The core and strength member shall be protected by a silver plated Kapton tape binder for electrostatic cleanliness.
5. The cable assembly shall be protected by an outer silver plated copper braid.

3 Mechanical Requirements

3.1 Design parameters

The SPB structural elements shall be designed to survive the environmental test requirements set forth by ref [6]. Table 3.1 lists some SPB mechanical design requirements:

Parameter	Value
Sphere diameter	8 cm
Keyreel pullout force	0.3 lb nominal ⁽¹⁾
Fine wire length	3 m
Fine wire strength	4x strength factor ⁽²⁾
Composite cable length	47 m ⁽³⁾
Composite cable mass rate	< 4g/m
Spool pullout force	3 lbs
Over tension switch force	12 lbs (~3x pullout force)
Meter wheel shear pin	35 lbs (~3x EOW force)
Composite cable strength	150 lbs (~4x shear pin strength)
Overall mass	<2.42 kg

(1) Force based on sphere mass and deploy sequence

(2) Strength based on sphere mass, smallest diameter wire most desirable

(3) Length based on 100m sphere tip-to-tip length and cable root radius

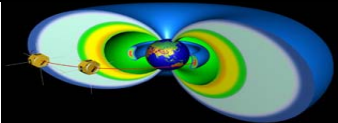
Space Sciences Lab University of California, Berkeley	PROCEDURE	 Radiation Belt Storm Probe RBSP-EFW-SPB-001 Specification-GD.doc Rev. A
TITLE: SPB Specification		

Table 3.1 SPB mechanical design requirements

3.2 Subassembly Design Requirements

3.2.1 Sphere Sensor

1. The spheres DAG-213 finish shall be applied with an airbrush for uniformity.
2. The sphere shall be designed for ease of removal, in the event of damage during flight qualification that may require refinishing prior to final stow and integration to s/c.
3. The keyreel constant force spring shall deploy the sphere sensor at a force consistent with the spacecraft final spinrate requirements and designed deploy sequence per ref [5].

3.2.2 Preamplifier Enclosure

1. Preamp design will allow for de-integration of sphere sensor without having to remove preamp PWB.
2. Preamp outer biased surfaces will have DAG-213 finish, applied with an airbrush for uniformity.

3.2.3 Spool

1. The spool shall be designed to allow the removal of the cable assembly without complete disassembly of SPB structure, allowing for replacement of the cable.
2. The SPB chassis shall be electrically insulated from the cable.
3. The cable over tension switch shall be wired in the 'normally open' position.

3.2.4 Meter Wheel

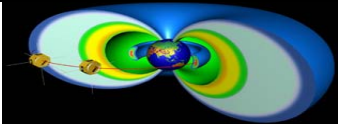
1. The meter wheel shall have a cam and microswitch to meter the cable deployment, wired in the 'normally open' position.
2. The meter wheel shall be electrically isolated from the cable.
3. The meter wheel cover shall be easily accessible and pinch rollers easily removable for stowing of cable.
4. Vulcanized rubber shall be used on the pinch rollers and meter wheel to add friction to produce the capstan force required to pull cable off the spool.
5. A shaft shear sleeve shall be used to allow removal of meter wheel for stowing of cable without removing shear pin.

3.2.5 Motor

1. Motor and output gears shall be sized with 10x design margin for gear train stress and 3x meter wheel shear pin force.
2. The motor shall be vacuum service prepared, including gearbox grease (Braycote 602EF), bearing lubrication (dry film), motor brush material substitution (SM389).
3. The motor permanent magnets shall be shielded using mu metal.
4. An EMI shield with power line filters will be used on the motor.
5. Motor will have a diode in between power terminals for back-EMF dissipation.

3.2.6 Door Release Mechanism and Snout

1. The release ring mechanism shall have redundant circuitry and an internal end-of-travel switch that secures power to the circuit when release ring has actuated.

Space Sciences Lab University of California, Berkeley	PROCEDURE	 Radiation Belt Storm Probe RBSP-EFW-SPB-001 Specification-GD.doc Rev. A
TITLE: SPB Specification		RBSP-EFW-SPB-001 Specification-GD.doc Rev. A

2. Release pins shall be spring loaded to allow for compliance and equalized door loading.
3. Each doors shall have a 'completely open' door indicating microswitch, wired in the 'normally open' position.
4. The preamp and sphere shall be electrically insulated from all SPB components.
5. While stowed, there shall be a contact to the sphere sensor to inject an AC test signal.

3.2.7 Structure

1. The structure shall have a first natural frequency higher than 100hz.

3.3 Packaging

The SPB will conform to the dimensions as seen in figure 3.3.1.

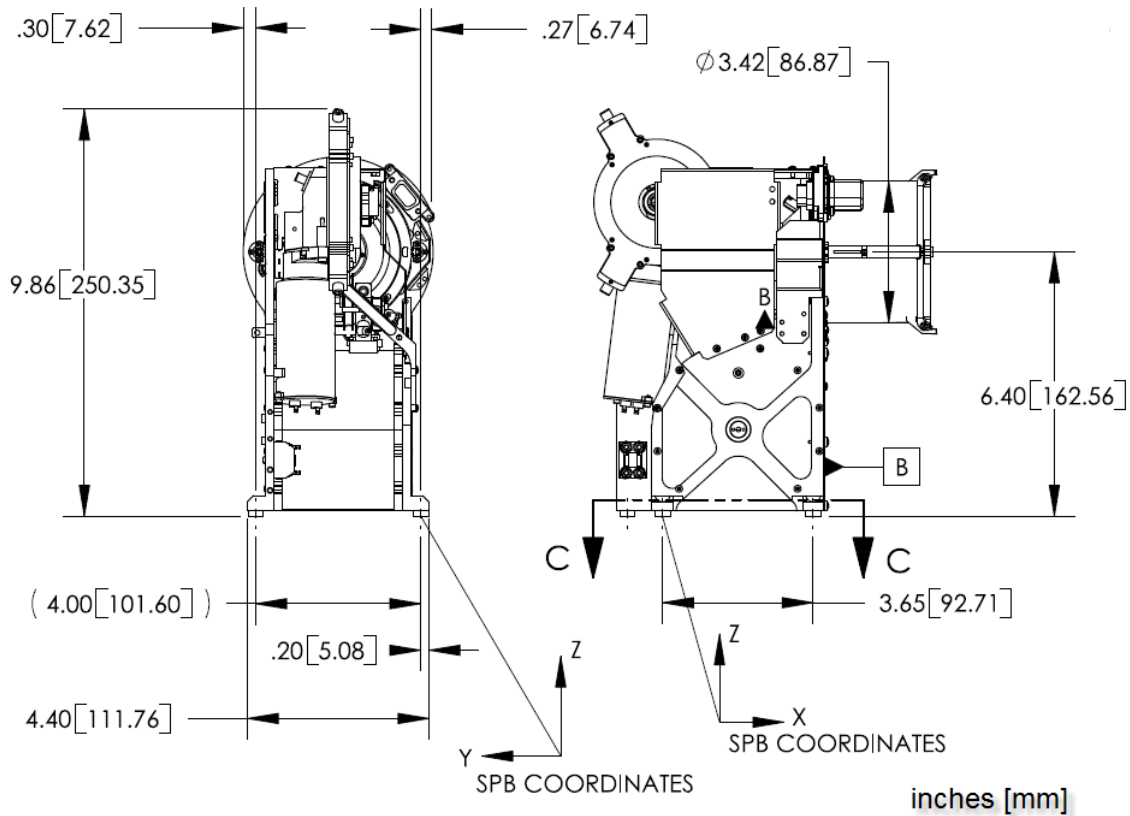


Figure 3.3.1 SPB envelope