RBSP
Radiation Belt Storm Probes

RBSP Science Working Group

EFW Boom Assessment & Spacecraft Spin Rate Change

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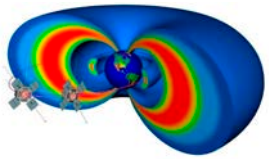
August 20, 2012

APL

Final Deployment Testing at Astrotech

Solar array and boom Deployment testing and final mag boom alignments

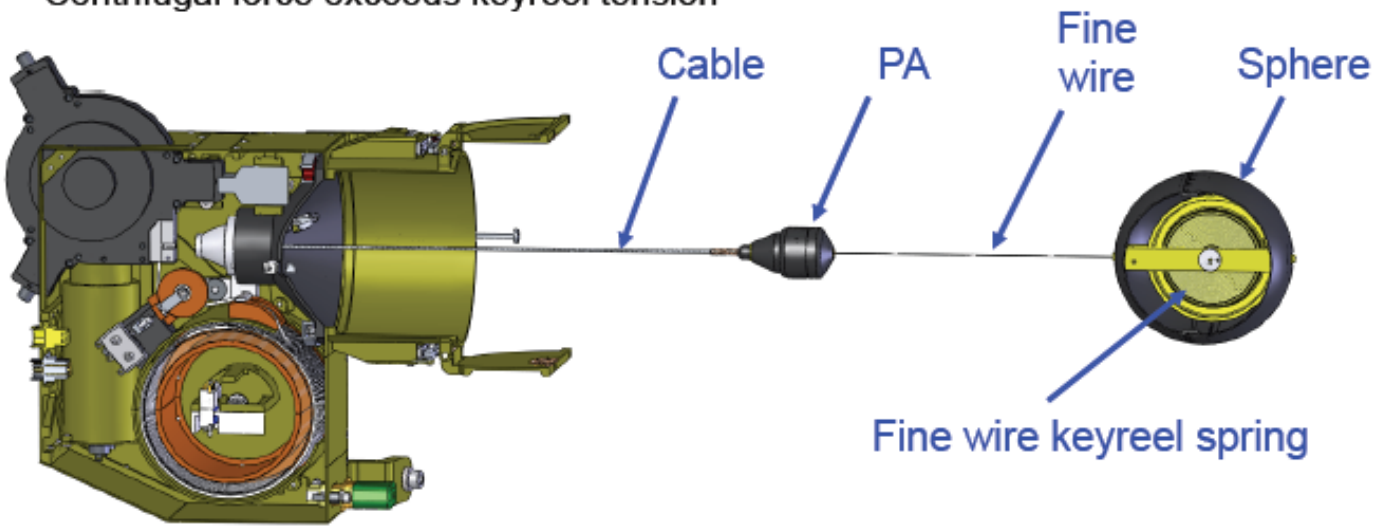
EFW SPB Issue Summary



- EFW team has found that changes to spin plane boom lengths and spacecraft spin rate will be necessary to keep fine wire segments for the spin plane booms deployed
  - Identified during review of deployment analysis
  - Actual preamp mass is lower than used for keyreel spring sizing
  - Seriously compromises both AC and DC field measurements
- Recommended option is to extend all 4 spin plane booms so that both pairs have 100-m dipole length
  - Each boom extends out to 50-m from spacecraft center line (+Z axis)
- Operational spin rate required > 4.9 rpm, so would target nominal spin rate away from this value
  - New operational spin rate target is 5.5 +/- 0.25 RPM; to be adjusted during commissioning and after initial precession maneuvers

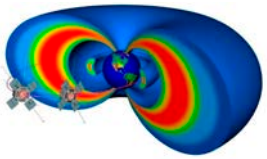
EFW SPB Operation

- **Deployment**
  - Doors open
    - Sphere remains stowed due to keyreel spring tension
  - Motor deploys cable ~.6cm/s with clicks at ~5cm intervals
    - Sphere exits housing
  - At 10m and 15RPM, fine wire unfurls
    - Centrifugal force exceeds keyreel tension



From Goetz: EFW SPB Options 20120804

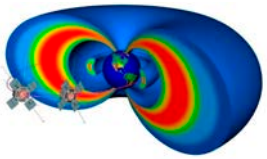
Impact Assessment for 50/50-m EFW SPB Deployment and Increased spin rate



- Extending lengths of one pair of booms to 50-m increases spacecraft inertia.
  - EFW reduced preamp mass offsets some of this increase.
- Higher spin rate and inertia increases torque needed to change spin axis direction during precession maneuvers
  - More thruster pulses needed per maneuver
  - Increases maneuver durations
- Estimates of propellant usage for precession maneuvers have been updated using new inertia and spin rate values
  - Results are summarized in the following slides
  - Comparison with values for original boom lengths is included
- G&C team also ran updated Monte Carlo and stability analyses to ensure nothing unexpected occurred during precessions
- Final spin balance and mass spacecraft mass properties updates were also included and with updated boom configuration and spin rate there is minimal impact on mission life.

From Rogers, Vaughan, Fosbury : GC Analysis 081012

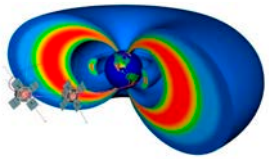
Impacts of EFW configuration change



- **Extending EFW to 50/50-m configuration will increase propellant usage, 3.3 kg (worst case) above previous budget.**
  - Still have ~ 20 kg of margin at end of primary mission
  - Still have propellant for more than 2x mission life
- **Extending EFW to 50/50-m configuration will increase maneuver time by 33-35% per maneuver**
  - A typical precession maneuver duration at BOL increases from 2 hours 15 minutes at beginning of life to about 3 hours
- **Extending EFW to 50/50-m configuration does not dramatically impact precession or spin rate change maneuver dynamics or stability**
  - Spacecraft is still a stable, major axis spinner
- **Instruments are designed to operate 4-6 rpm.**

RBSP is ok for implementing the option of deploying EFW spin plane booms to 50/50-m configuration & increasing spin rate

Propellant Usage for Precession Maneuvers



8/12 Original Boom Length
8/12 Extended Boom Lengths

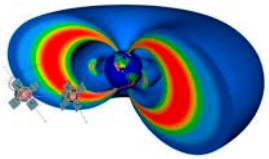
Full tank capacity 56 kg
Launch tank loads 56.49 ± 0.01 kg

Spin Rate (rpm) ⇒ Sun Offset Angles ⇓	4.9	5.0	5.25	5.5	6.0
Minimum: NS 15.4 deg EW 8 deg	10.4 / 12.3 kg	10.6 / 12.5 kg	11.1 / 13.2 kg	11.7 / 13.8 kg	12.8 / 15.1 kg
Nominal: NS 19 deg EW 11.6 deg	11.0 / 13.0 kg	11.2/ 13.2 kg	11.8 / 14.5 kg	12.4 / 14.6 kg	13.5 / 16.0 kg
Maximum: NS 22.6 deg EW 15.2 deg	11.5 / 13.5 kg	11.7 / 13.8 kg	12.3 / 14.5 kg	12.9 / 15.2 kg	14.1 / 16.6 kg This case used for CDR propellant budget
OPS: NS 19 deg EW Varying	10.8 / 12.8 kg	11.0 / 13.0 kg	11.6 / 13.7 kg	12.2/ 14.3 kg 12.8 kg nominal- w/final mass props	13.3 / 15.7 kg

All entries include 10% margin

From Rogers, Vaughan, Fosbury : GC Analysis 081012

Propellant Budget
Previous vs. 08/12 Update



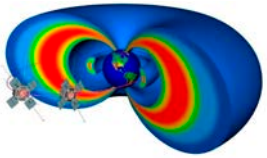
- Two-year, 60 day mission
  - Commissioning (Phasing, Spin Rate Adjustments)
  - Primary Mission (Precessions, Spin Rate Adjustments)
  - Deorbit (Delta-V maneuvers at Apogee/Perigee)
- G&C precession requirement is value which includes10% QMS margin, maximum spin rate (6 rpm), maximum sun offset angles (NS 22.6º, EW 15.2º), max measured spin axis inertia (2348 vs. 1993 kg·m^2), and a worst-case (80 psi) EOL Isp of 203 seconds.
- G&C spin up/down requirement (TBR) includes 10% QMS margin and Isp =203 s.

Propellant Budget:	ΔV	08/12 Max Update	Previous Max Values	Final Nominal Values
MD - Phasing/Collision Avoidance:	2.4 m/s	0.77 kg	0.77 kg	.77 kg
G&C - Precession:		16.60 kg	13.30 kg	12.8 kg
G&C - Spinup/Spindown:		0.28 kg	0.28 kg	.28 kg
MD - Deorbit:	59.6 m/s	18.31 kg	18.31 kg	18.31 kg
Additional N2H4 to fill tanks		19.97 kg	23.28 kg	23.78 kg
Residual Propellant:		0.56 kg	0.56 kg	.56 kg
Total Propellant Mass:		56.49 kg	56.49 kg	56.49 kg
Total GN2 Pressurant Mass:		0.55 kg	0.55 kg	.55 kg

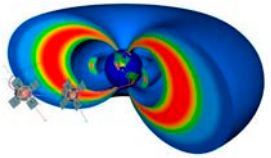
Each RBSP spacecraft has propellant onboard for > 5.5 years of nominal operation (est.)

From Rogers, Vaughan, Fosbury : GC Analysis 081012

Spin Rate Feedback from SWG



- **Please email any comments or concerns about the spin rate change and impact on science to:**
  - Karen.Kirby@jhuapl.edu and Jim.Stratton@jhuapl.edu

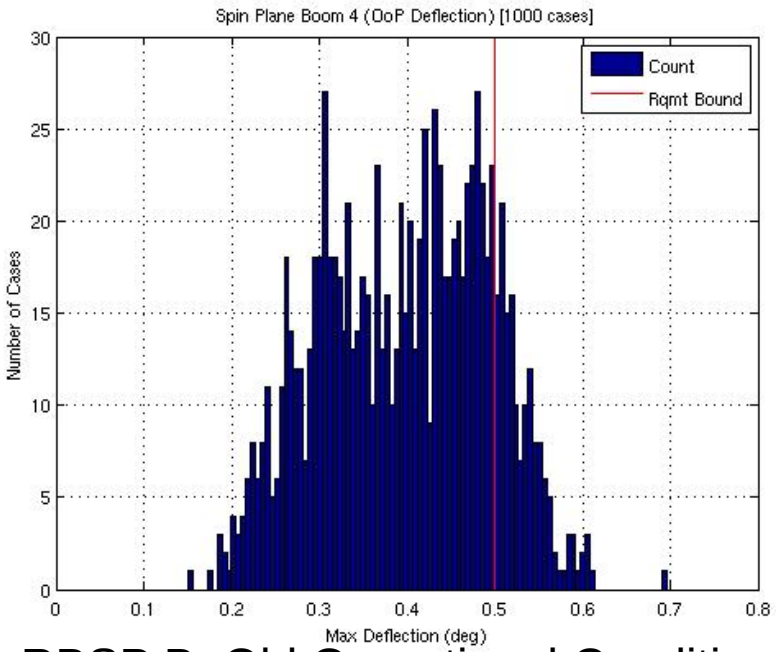


Backup

Monte Carlo Analyses

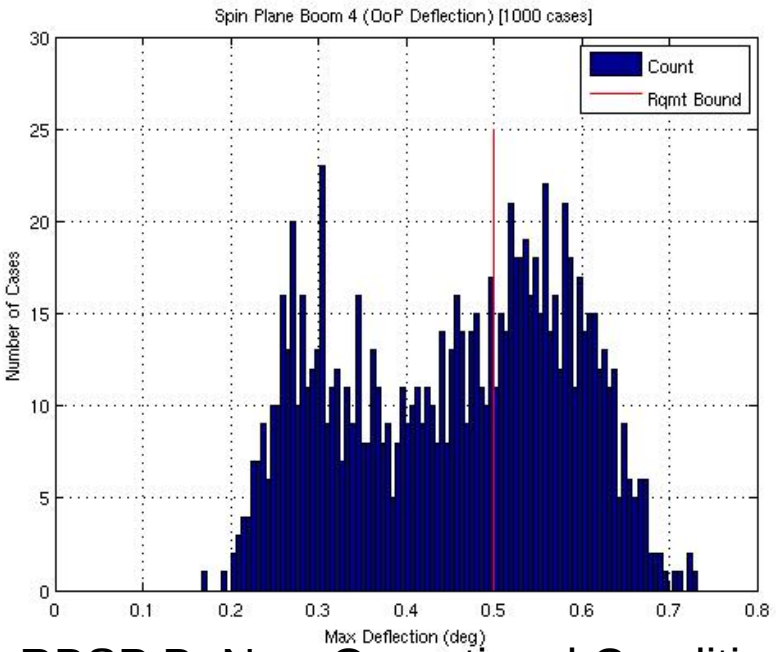
Spin Plane Boom #4 Deflection
Representative 21-day Precession (0.25 second pulses)

EFW boom at 50 m



RBSP B: Old Operational Conditions (40/50-m), 5.5 RPM, 56 kg propellant

EFW boom at 50 m



RBSP B: New Operational Conditions (50/50-m), 5.5 RPM, 56 kg propellant