National Aeronautics and Space Administration

PRESS KIT | AUGUST 2012

Radiation Belt Storm Probes Launch

www.nasa.gov

Table of Contents

Media Contacts

Launch Operations
Kennedy Space Center, Fla.
George Diller
321-861-7643
George.H.Diller@nasa.gov

Atlas V Launch Vehicle
Cape Canaveral Air Force Station, Fla.
Jessica Rye
321-730-5646
Jessica.F.Rye@ulalaunch.com

NASA Public Affairs
Dwayne Brown
Office of Public Affairs
Science Mission Directorate
NASA Headquarters, Washington
202-358-1726
Dwayne.C.Brown@nasa.gov

The Johns Hopkins University Applied Physics Laboratory
Geoff Brown
Office of Communications and Public Affairs
The Johns Hopkins University Applied Physics Laboratory
Laurel, Md.
240-228-5618
Geoffrey.Brown@jhuapl.edu

NASA Heliophysics Division
Jennifer Rumburg
Communications Officer
Science Mission Directorate
NASA Headquarters, Washington
202-358-2484
Jennifer.Rumburg@nasa.gov

Media Services Information

NASA Television Transmission

In the continental United States, NASA television's Public, Education and Media channels are carried by MPEG-2 digital C-band signal accessed via satellite AMC-6, at 72 degrees west longitude, transponder 17C, 4040 MHz, vertical polarization. In Alaska and Hawaii, they are available on an MPEG-2 digital C-band signal accessed via satellite AMC-7 at 137 degrees west longitude, transponder 18C, at 4060 MHz, vertical polarization. A Digital Video Broadcast–compliant integrated receiver Decoder with modulation of QPsK/DBV, data rate of 36.86 and FeC 3/4 is required for reception. NASA TV Multichannel Broadcast includes:

- Public Services Channel (Channel 101)
- Education Channel (Channel 102)
- Media Services Channel (Channel 103)

Analog NASA TV is no longer available. For digital downlink information for each NASA TV channel, access to NASA TV's Public Channel on the Web and a schedule of programming for Radiation Belt Storm Probe (RBSP) activities, visit http://www.nasa.gov/ntv.

Media Accreditation and Media Access Badges for Kennedy Space Center

All news media, including those who are permanently badged, must complete the accreditation process for the activities associated with the RBSP launch. The press accreditation process may be done via the Web by going to https://media.ksc.nasa.gov/. Journalists may contact the KSC newsroom at 321-867-2468 for more information.

Briefings

An overview of the RBSP mission will be presented at NASA Headquarters in Washington and will be broadcast on NASA TV, originating at 1 p.m. EDT on Aug. 9, 2012. A prelaunch mission briefing will be held at Kennedy Space Center at 1 p.m. EDT on Aug. 20, 2012, followed by a briefing about the RBSP mission's science goals and capabilities. A post-launch briefing at KSC will begin approximately two and a half hours after launch to provide an update on mission status. These news conferences will be broadcast live on NASA Television. Journalists may contact the KSC newsroom at 321-867-2468 or any RBSP public affairs officer to arrange interviews with team members.

Specific information and scheduling details about upcoming briefings will be kept current at http://www.nasa.gov/rbsp.

NASA and RBSP on the Internet

Information about NASA's RBSP mission, including an electronic copy of this press kit, press releases, status reports and images, is available at http://www.nasa.gov/rbsp and http://rbsp.jhuapl.edu/index.php. Frequent updates about the mission, together with public feedback, are available on Facebook at https://www.facebook.com/pages/Radiation-Belt-Storm-Probes-RBSP/180502091967513, on Twitter at http://www.twitter.com/RBStormProbes; and on YouTube at http://www.youtube.com/user/RBStormProbes.

NASA's Radiation Belt Storm Probes

The Radiation Belt Storm Probes (RBSP) are twin spacecraft designed to fly and operate in the heart of the most hazardous regions of near-Earth space and collect crucial data. That data will let researchers finally begin to unlock the mysteries of the Van Allen radiation belts, two donut-shaped rings around the Earth made up of very high energy electrons and protons that can damage satellites and endanger humans during spaceflight.

RBSP will give scientists the data they need to understand how the invisible radiation belts (named for their discoverer, James Van Allen) behave and react to changes in the sun, thereby contributing to Earth's space weather. Space weather is caused in great part by the sun's influence on the Earth and near-Earth space, and by such solar events as coronal mass ejections (CMEs).

Space weather fluctuations can increase the dose of radiation that pilots and passengers receive during polar aircraft flights, disable satellites, cause power grid failures, and disrupt Global Positioning System, television, and telecommunications signals. Understanding the science of space weather could one day help us to predict space weather – which in turn will allow us to better manage and protect technologies in space and on the ground.

The two-year RBSP mission will, for the first time, fly two satellites – carrying the best and most comprehensive instrumentation ever sent into the radiation belts – through surging and swelling belts of energized particles that would damage ordinary spacecraft. By using two spacecraft, scientists will be able to study the radiation belts over both space and time, providing a previously unavailable picture of how particles within the belts are produced and behave during space weather events, and what mechanisms drive the acceleration and loss of the particles.

The lessons learned about how particle acceleration works in the radiation belts can be applied to other objects and events across the universe. Understanding the belts and their variability is important for both fundamental physics knowledge, and will also have extremely important practical applications in the areas of understanding space weather and in spacecraft design and operations, mission planning, and astronaut safety.

RBSP is part of NASA's Living With a Star program to explore aspects of the connected sun-Earth system that directly affect life and society.

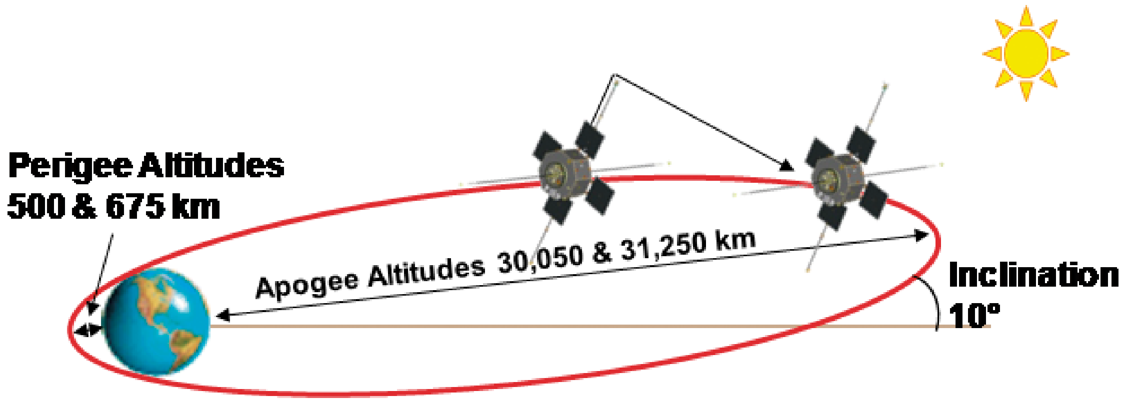
Mission Quick Facts

Launch: Aug. 23, 2012 (4:08 – 4:28 a.m. EDT). RBSP can launch on any day of the year, at approximately 4:00 am EDT.

Launch Site: Cape Canaveral Air Force Station, Fla., Launch Complex 41

Launch Vehicle: United Launch Alliance Atlas V 401 rocket

Orbit: The two RBSP spacecraft will fly in nearly identical eccentric orbits that cover the entire radiation belt region. The spacecraft orbits will have apogee altitudes between 30,050 kilometers (18,672 miles) and 31,250 km (19,417 mi), perigee altitudes between 500 km (311 mi) and 675 km (419 mi), and inclination of 10 degrees from the equator. RBSP are sun-pointing spacecraft.



Orbital Period: Both spacecraft have nine-hour orbit periods. The orbits are designed to allow one observatory to lap the other approximately every 75 days. Apogees that differ slightly (by approximately 100 km) allow for simultaneous measurements to be taken over the full range of observatory separation distances during the course of the mission.

Mission Operations: RBSP's mission operations center (MOC) is located at the Johns Hopkins University Applied Physics Laboratory, Laurel, Md.

Mission Facts:

- RBSP is a twin spacecraft mission: By providing measurements from identical sets of instruments aboard each spacecraft, scientists will be able to study how the radiation belts change.

  Why two spacecraft?
  By having identical instruments on two spacecraft that follow each other along (nearly) the same path, scientists can, for the first time ever, measure changes in the radiation belts over both space and time. As just one example, imagine that a single RBSP probe detects an increase in radiation at point A. With that single spacecraft there is no way of knowing whether the increase occurred because the spacecraft crossed a spatial boundary or because there was an increase in time over an extended spatial region. If the second spacecraft does not see an increase until it too gets in the vicinity of point A, then the increase resulted from spatial structure rather than from a change in time. With two spacecraft, various scenarios of changes in space and time can be studied and discriminated.

- In addition to the comprehensive science data that RBSP will be sending down when the spacecraft are in sight of their primary downlink stations (about 2.5 hours per day for each spacecraft), RBSP will also broadcast data on space weather conditions about 90 percent of the time for 24 hours a day, seven days a week, via a signal that can be acquired and monitored by registered users (see "RBSP's Space Weather Broadcast," p. 23, for details).

Spacecraft Quick Facts

Satellite: Each RBSP spacecraft will operate independently in a spin-stabilized mode, at about 5 revolutions per minute (rpm), with the spin axis nearly sun-pointed and maintained between 15 and 27 degrees away off from the sun, with four deployed solar array panels and eight deployed instrument booms.

Duration: The probes have a two-year prime science mission and are designed to operate for an additional period of time.

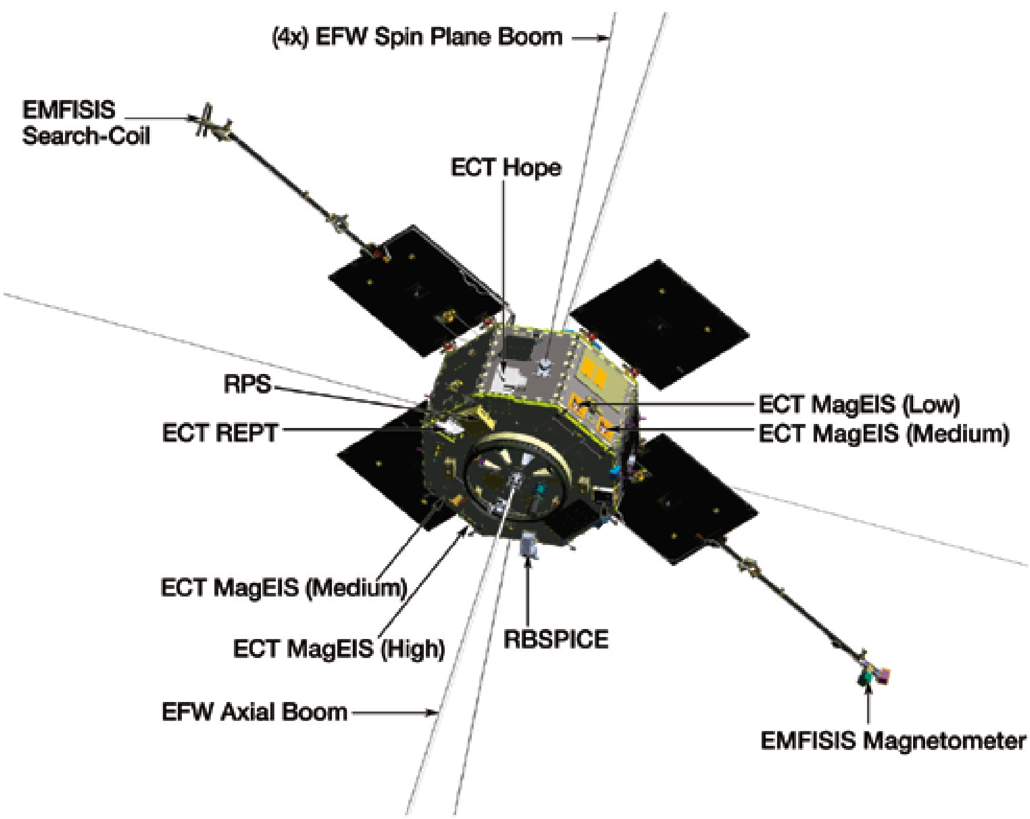
Mass: The total mass of each spacecraft at launch is 647.6 kilograms (1,427.7 pounds) for spacecraft A and 666.6 kg (1,469.6 lbs) for spacecraft B; which includes spacecraft systems with mass of 444 kg (978.8 lbs) on spacecraft A and 463 kg (1,020.7 lbs) on spacecraft B; instruments with mass of 129.6 kg (285.7 lbs) on each spacecraft and fuel with mass of 56 kg (123.5 lbs) onboard each spacecraft.

Spacecraft B has more mass because it carries more mechanical systems and pieces related to attachment to and separation from both the launch vehicle and spacecraft A. Apart from those differences, the design of the two spacecraft is identical.

Power: The spacecraft supports a spacecraft and instrument load of 350 watts, using a total area of 3.2 square meters (3.8 square yards) of solar arrays spread out on four panels.

Instruments: Each RBSP spacecraft carries an identical set of five instrument suites: The Energetic Particle, Composition, and Thermal Plasma Suite (ECT), the Electric and Magnetic Field Instrument Suite and Integrated Science (EMFISIS), the Electric Field and Waves Suite (EFW), the Radiation Belt Storm Probes Ion Composition Experiment (RBSPICE), and the Relativistic Proton Spectrometer (RPS).

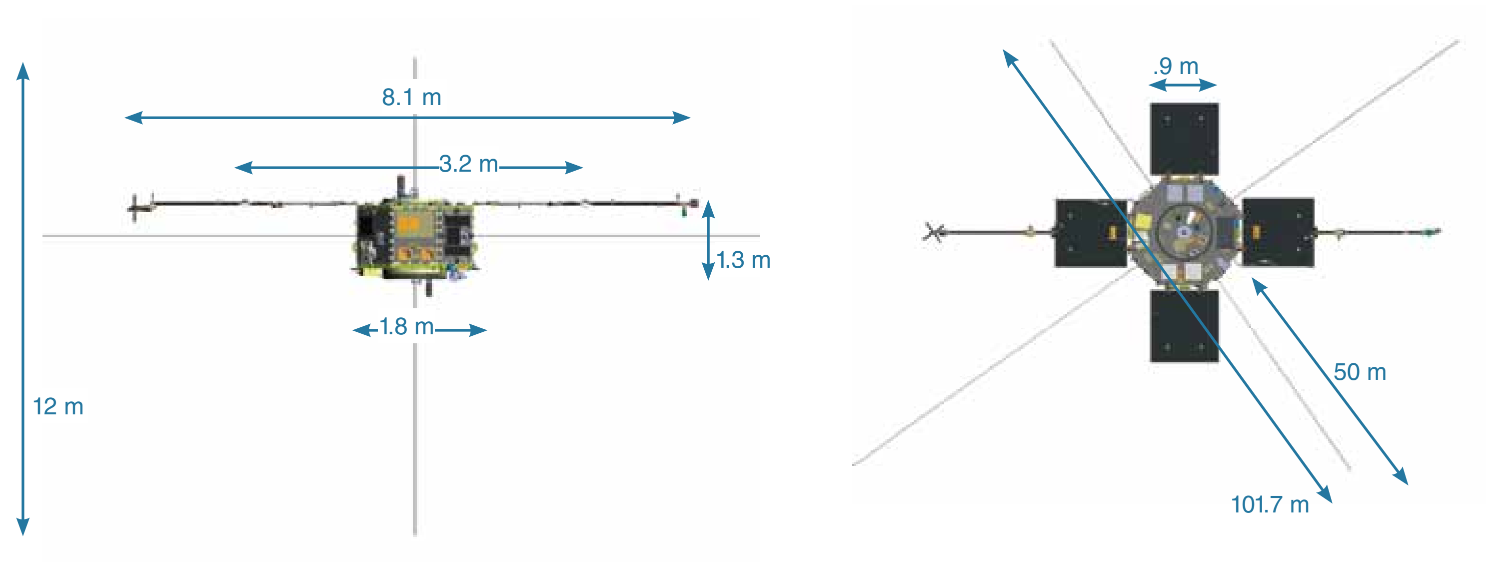
RBSP Spacecraft (both A and B)



The RBSP spacecraft and instruments; instruments are in identical locations on both spacecraft

RBSP dimensions: The overall width and length of each octagonal spacecraft side is 0.9 m (2.9 ft). The spacecraft main body is 1.8 m (5.9 ft) across by 1.3 m (4.3 ft) tall.

- The span of the spacecraft with solar panels deployed is 3.2 m (10.5 ft) across.
- The span of the spacecraft with solar panels and magnetometer booms deployed is 8.1 m (26.6 ft) across.
- The spacecraft span with EFW instrument wire booms fully deployed is 101.7 m (333.7 ft), tip to tip. Each wire boom is approximately 50 m (164 ft) long.
- The spacecraft height with EFW instrument axial booms deployed is 12 m (39.4 ft), tip to tip.



Not to scale. Full length not shown on booms.

Antennas: The RBSP spacecraft radio frequency (RF) system includes two broadbeam S-band antennas with 70 degree field of views, one on top of the spacecraft and one of the bottom of the spacecraft transmitting simultaneously to provide almost continuous coverage while the spacecraft travel around the earth.

Maximum Downlink Rate: RBSP's RF system can send data back at rates up to 2 megabits per second (Mbps) at S-band frequency of 2 gigahertz (GHz). The RF system is sized to enable downlinking of at least 6.61 GB of data per day per spacecraft, including science as well as real-time housekeeping telemetry.

Spacecraft Details

Composition: The primary structure is an aluminum forged cylinder and the structure panels and decks are honeycomb core with aluminum facesheets. The mechanical design includes hinged panels that provide easy access for installation and integration of spacecraft components.

Avionics computer: RBSP's on-board avionics computer is based on a BAE RAD-750 radiation hardened processor with 16 MB of RAM plus a 16 GB SDRAM data recorder. The spacecraft interfaces are controlled by a customized radiation-tolerant RTAX2000 FPGA (field-programmable gate array) microprocessor.

Propulsion systems: The RBSP propulsion subsystem is a monopropellant hydrazine system that provides orbit maintenance, spin-rate adjustments, and changes in velocity for each spacecraft. The propulsion system consists of eight 0.9 Newton (0.2 pound force, or lbf) Aerojet MR-103G thrusters. The propellant and pressurant (needed to move the propellant through the system) are stored in the three identical tanks, which are spaced equally around the spacecraft spin axes.

Communications: The spacecraft-to-ground communication link provides the capability to transmit all science and housekeeping data for 2.5 hours each day for each spacecraft, after commissioning at a rate of 0.5 bps. At all other times the spacecraft will be transmitting space weather data.

Ground Stations: RBSP will communicate with Earth using three ground stations. The primary ground station will be the 18 meter (60 feet) satellite dish at the Johns Hopkins University Applied Physics Laboratory in Laurel, Md. The two other ground stations are part of the Universal Space Network (USN) and are 13 meter (43 foot) dishes located at different points on the globe (Hawaii and Australia) to maximize coverage.

Power: The RBSP spacecraft battery provides enough power for full science operations during times when the spacecraft are in Earth's shadow and sunlight cannot reach their solar panels. The daily eclipse times vary throughout the mission, depending on when the spacecraft launch, though the longest eclipse period is 115 minutes.

Mission Overview

The Radiation Belt Storm Probes (RBSP) are two rugged spacecraft designed to gather scientific data about, and from within, the most hazardous area of near-Earth space: the radiation belts. The mission is designed to help us understand the sun's influence on the Earth and near-Earth space by studying the planet's radiation belts (named for their discoverer, James Van Allen) on various scales of space and time, using – for the first time – two identically instrumented spacecraft flying right through the belts.

What are the Radiation Belts?

In 1958, the team led by University of Iowa professor James A. Van Allen, using observations from Explorer 1 (the first American satellite), made the surprising discovery that intense radiation – highly-energized charged particles – is trapped by our planet's magnetic field. Later space missions revealed that the radiation occurs in two swaths around Earth, now called the Van Allen Radiation Belts. The inner, relatively stable belt, composed mainly of protons, extends from the top of the atmosphere out to an altitude of some 4,000 miles. The outer belt, composed mainly of high-energy, fast-moving electrons, extends from about 8,000 miles to more than 26,000 miles above Earth's surface.

We now know that intense particle radiation occurs around other planets and in other regions of our solar system, and throughout the entire universe. But how this radiation is created and behaves remains a mystery. Earth's radiation belts can respond in unexpected ways, often quite suddenly and dramatically swelling and shrinking in response to dynamic changes in the sun.

Why study the Radiation Belts?

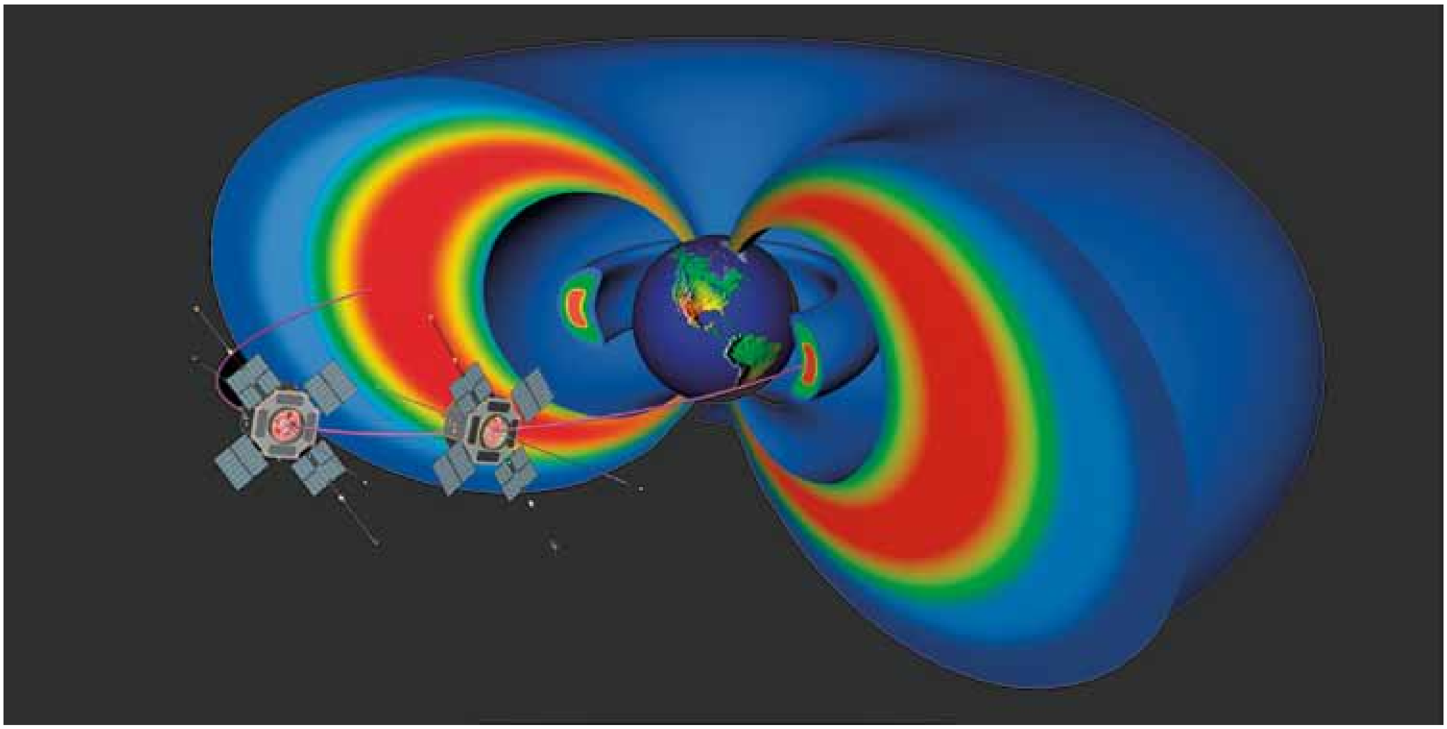
Understanding the radiation belt environment and its variability is important for two reasons. First, it advances fundamental physics knowledge about space processes, and second, it will allow mitigation of space weather in areas of spacecraft design and operations, mission planning, and astronaut safety.

The instruments on the twin RBSP spacecraft will provide the measurements needed to characterize, quantify, and understand the processes that produce the populations of energetic charged particles that comprise the Earth's radiation belts and cause them to vary dramatically. These processes of particle acceleration apply not only to the belts but to other objects and events across the solar system and universe.

Space weather can change the ionizing radiation dose on polar aircraft flights, disable satellites, cause power grid failures, and disrupt global positioning system, television, and telecommunications signals. Understanding the science of space weather can lead to a capability for prediction, which will allow for better management and protection of space-based or – affected technologies. The total life-cycle cost of the RBSP mission is $686 million.

RBSP General Science Objectives

- Discover which processes that – singly or in combination – accelerate and transport the particles in the radiation belts to create radiation belt enhancement events, and under what conditions
- Understand, quantify, and determine the dominant mechanisms for the loss of energetic electrons and protons from the radiation belts
- Determine the balance between the processes that cause electron acceleration and those that cause losses
- Understand how the radiation belts are affected by geomagnetic storms and related processes.



Artist's rendering showing a cutaway of Earth's radiation belts together with two (not to scale) representations of the Radiation Belt Storm Probes The red areas show concentrations of the highest intensity energy charged particles. While the inner belt remains in roughly the same shape during geomagnetic storms, those same storms can cause the outer belt to swell and fluctuate wildly in size and intensity.

RBSP Instruments

Each RBSP spacecraft carries an identical set of five instrument suites. The science instrument systems are designed to run independently (decoupled) from basic spacecraft systems such as communications and propulsion. The science instrument teams can run all of their instrument operations on their own without worries of conflicting needs for spacecraft resources with the mission operations team.

The Energetic Particle, Composition, and Thermal Plasma Suite (ECT) is a suite of three highly-coordinated particle instrument types designed to ensure the highest quality measurements ever made in the inner magnetosphere. The ECT will measure the speed, direction and composition of particles in the Van Allen radiation belts, including electrons, protons, and charged ions of oxygen and helium over an unprecedented range of energies. The coordinated ECT particle measurements, analyzed in combination with observations from other instrument, and using state-of-the-art theory and modeling, will provide understanding of the acceleration, global distribution, and variability of radiation belt electrons and ions. The ECT's Principal Investigator is Dr. Harlan Spence of the University of New Hampshire.

The Electric and Magnetic Field Instrument Suite and Integrated Science (EMFISIS) will focus on the important role played by magnetic fields and plasma waves in the processes of radiation belt particle acceleration and loss. Plasma waves propagate within the sparse, low energy ionized gases (plasmas) that occupy the same regions of space that contain the radiation belts, and are analogous to sound waves that propagate within the air around us. EMFISIS will differentiate between the processes that help provide energy and speed to particles in the belt and those that lead to their being ejected from the belts altogether. EMFISIS provides understanding of the origin of important magnetospheric plasma wave types as well as the evolution of the magnetic field that defines the basic coordinate system controlling the structure of the radiation belts and the storm-time ring current. The ring current is a region of electric currents encircling Earth, carried by hot ionized gases (plasmas), that causes distortions in the magnetic field configuration during magnetic storms. Dr. Craig Kletzing of the University of Iowa, Iowa City is the Principal Investigator.

The Electric Field and Waves Suite (EFW) will study the electric fields in near-Earth space that energize radiation particles and modify the structure of the inner regions of Earth's space environment, or "magnetosphere." EFW will observe electric field structures in space – from those that extend only half a mile long to those that extend over 100,000 miles long – in order to determine which fields cause the most change in the structure of the magnetosphere. The experiment also focuses on the plasma waves that carry electromagnetic fields that can energize charged particles. This investigation consists of a set of four spin-plane electric field (E-field) antennae and a set of two spin-axis stacer (tubular, extendable) booms. The investigation will provide understanding of the electric fields associated with particle energization, scattering and transport, and the role of the large-scale electric fields in modifying the structure of the inner magnetosphere. EFW's Principal Investigator is Dr. John Wygant of the University of Minnesota, Minneapolis.

The Radiation Belt Storm Probes Ion Composition Experiment (RBSPICE) will determine how space weather creates what is called the "storm-time ring current" around Earth and determine how that ring current supplies and supports the creation of radiation populations. This instrument measures those hot charged particle distributions that carry the electric currents around the Earth that comprise the ring current. By doing so, this investigation will accurately measure the ring current pressure distribution which is the parameter needed to quantify the electric currents that are being carried. That information is then used to understand how the inner magnetosphere changes during geomagnetic storms and how that storm environment supplies and supports the acceleration and loss processes involved in creating and sustaining hazardous radiation particle populations. Dr. Louis Lanzerotti of the New Jersey Institute of Technology is the Principal Investigator.

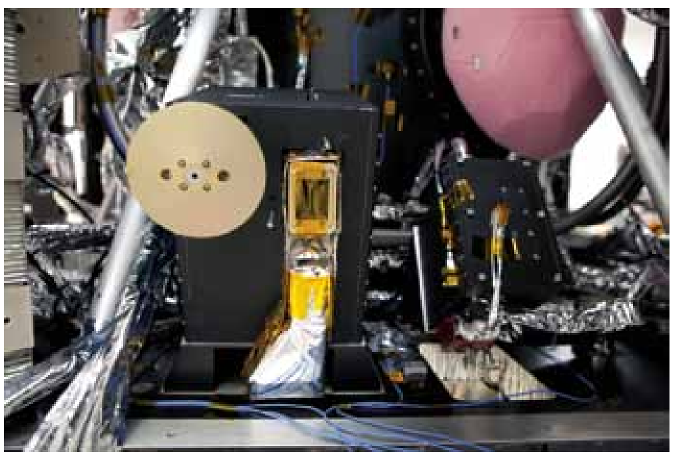
The Relativistic Proton Spectrometer (RPS) focuses on the inner radiation belt, which houses some of the highest energy protons in Earth's magnetic environment. Such protons are known to pose a number of hazards to astronauts and spacecraft, including total ionizing dose, displacement damage, single event effects, and nuclear activation. This instrument will address a priority highly ranked by the scientific and technical community and will extend the measurement capability of this mission to a range beyond that originally planned. The project's goal is development of a new standard radiation model for spacecraft design. The overarching investigation associated with this effort is the Proton Spectrometer Belt Research (PSBR) investigation with Principal Investigator Dr. David Byers of the National Reconnaissance Office (NRO). The Principal Investigator for the RPS instrument component to this investigation is Dr. Joseph Mazur of the Aerospace Corporation.

Energetic Particle, Composition, and Thermal Plasma Suite (ECT)

The **Energetic Particle, Composition, and Thermal Plasma Suite (ECT) suite** consists of three highly-coordinated instrument types (**MagEIS, HOPE**, and **REPT**) that will, for the first time, reveal comprehensively the types and make-up of energized particles in the radiation belts. ECT will do this by covering the full range of energy spectra across which electrons and ions exist in the belts (the energy of electrons and ions is measured in electron volts – eV). ECT can examine the energy range from one electron volt (eV) to tens of millions of eV (MeV) with sufficient energy resolution, pitch angle coverage and resolution, and can make ion composition measurements as well, discriminating between hydrogen, helium, and oxygen ions over large portions of the ECT energy range. Just by way of comparison, the energy of an average molecule of oxygen or nitrogen in the air that we breathe is about 1/40 eV (or 0.025 eV).

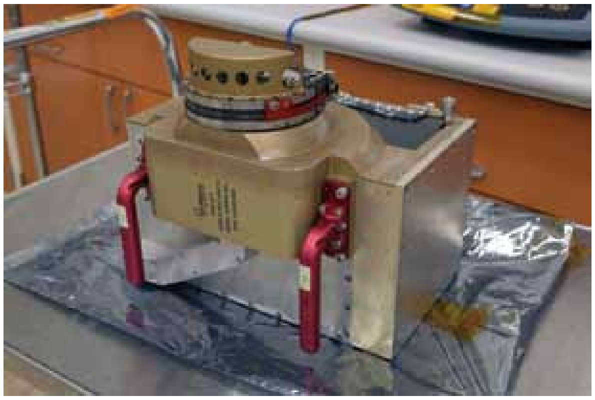
ECT has four science objectives: Determine the physical processes that produce radiation belt enhancements during geomagnetic storms; determine the dominant mechanisms for relativistic electron loss in the [outer?] radiation belt; determine how the inner magnetospheric plasma environment controls radiation belt acceleration and loss; and develop empirical and physical models for understanding and predicting radiation belt space weather effects.

All three of ECT's instrument types are based on proven radiation belt measurement techniques, optimized to provide unambiguous separation of ions and electrons, giving scientists a clear understanding of particle behavior in the belts. The instruments can derive clean energy responses even in the presence of extreme penetrating particle background environments. The instrumentation is also designed to operate in the harsh radiation environment of the belts, ensuring that ECT particle measurements have the fidelity needed to contribute answers to key RBSP science questions, as well as meet its own science objectives.



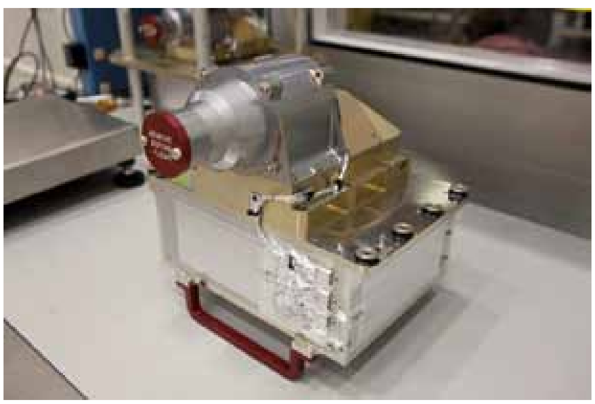
The MagEIS portion of ECT has four sensors per spacecraft. Above, MagEIS High installed on spacecraft A.

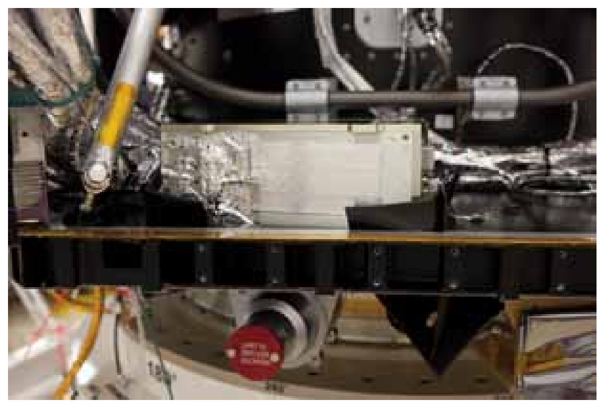
The **Magnetic Electron Ion Spectrometer (MagEIS)** instrument is a spectrometer (separating incoming particles by energy) that will use magnetic deflection and focusing, and pulse height analysis (measuring the amplitude of signals coming from multiple detectors) to provide the cleanest possible energetic electron and ion measurements. There are four separate MagEIS spectrometers measuring three different regions of electron energy: one High sensor, two Medium sensors, and one Low sensor. Ions are measured only within the High sensor. MagEIS covers the middle range of energies measured by the ECT investigation.



Above left: The Helium Oxygen Proton Electron (HOPE) instrument for spacecraft A; right, HOPE installed on spacecraft B

The **Helium Oxygen Proton Electron (HOPE)** mass spectrometer instrument (discriminating particles by energy and mass species) will use an electrostatic “top-hat” analyzer and time-gated coincidence detectors to accurately measure electrons, protons, and helium and oxygen ions, while filtering out and rejecting other particles. HOPE “looks” simultaneously into five different directions and measures, in each direction, the lower range of the energies measured by the ECT investigation.



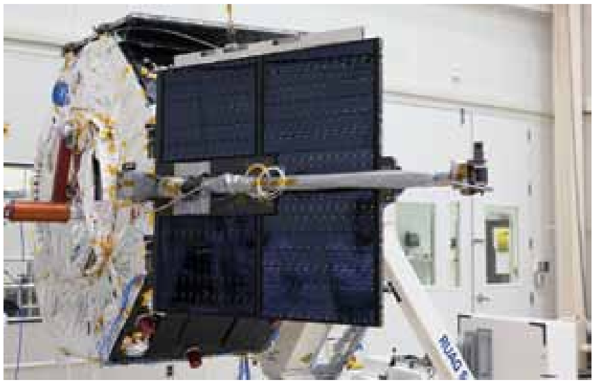


Above left: The Relativistic Electron Proton Telescope (REPT) instrument for spacecraft A; right, REPT installed on spacecraft B

The **Relativistic Electron Proton Telescope (REPT)** uses a stacked array of solid state detectors to measure the higher energy portion of the energies measured by the ECT investigation. For electrons it will cover a particularly challenging electron mass range (4 to 10 MeV) as well as the proton energy range of 20 to 70 MeV, in order to capture data on particle activity during the most intense geomagnetic storm events.

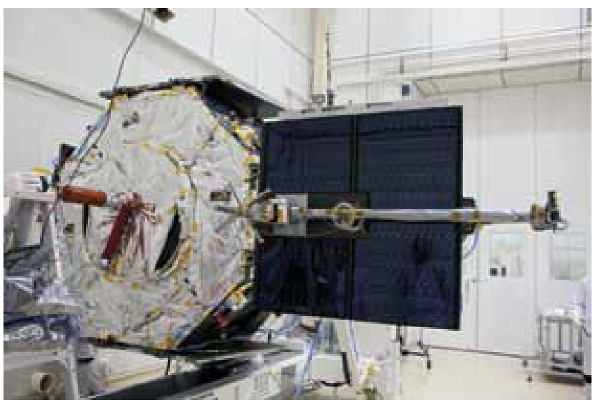
Electric and Magnetic Field Instrument Suite and Integrated Science (EMFISIS)

The Electric and Magnetic Field Instrument Suite and Integrated Science (EMFISIS) will, for the first time, provide the essential plasma wave measurements of magnetic and electric fields to unravel the physics of the interactions between the waves and charged particles that are responsible for acceleration, transport and loss of radiation belt particles. Additionally, the EMFISIS measurements of steady or slowly varying magnetic fields will provide information on much lower frequency phenomena such as the variations in the ring current that encircles Earth, and ultra-low frequency waves which transport particles. These field measurements, combined with excellent coverage of particle measurements from other RBSP instruments and investigations, promise to reveal the clearest picture ever obtained of radiation belt physics.



Above left: The EMFISIS tri-axial Fluxgate Magnetometer (MAG) boom, shown stowed on the deployed solar array of spacecraft A; right, the MAG boom shown after deployment on spacecraft A

EMFISIS consists of two types of magnetometers per spacecraft, each mounted on the end of separate three-meter booms which deploy from the edge of two opposing solar arrays. On one boom, the tri-axial Fluxgate Magnetometer (MAG) is mounted, consisting of three sensors to measure the background steady or slowly varying magnetic fields and ultra-low frequency waves. On the other boom is a tri-axial Magnetic Search Coil (MSC) magnetometer, which senses quickly varying wave magnetic fields.



Above left: The EMFISIS tri-axial Magnetic Search Coil (MSC) magnetometer boom, shown stowed on the deployed solar array of spacecraft A; right, the MSC boom shown after deployment on spacecraft A

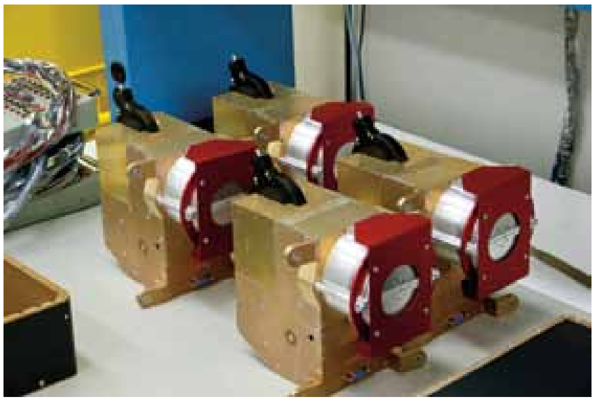
In addition to the two booms, EMFISIS also utilizes a spacecraft-mounted Central Data Processing Unit (CDPU), with 500 megabytes (MB) of mass memory, for instrument control, spacecraft interface, and on-board analysis. The CDPU is part of the EMFISIS Main Electronics Box (MEB) which also contains wave receivers, MAG control circuits, and special math co-processors to analyze and compress EMFISIS Waves data.

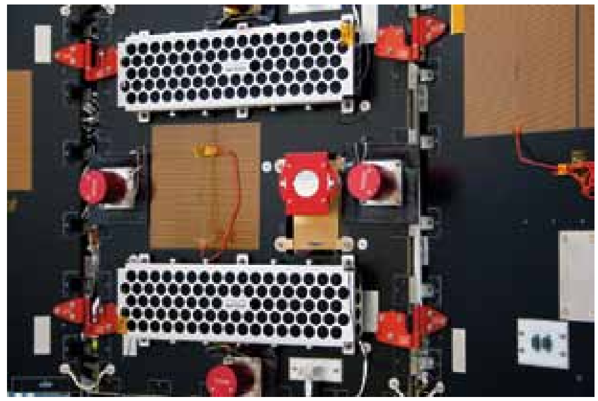
EMFISIS has five primary scientific objectives. Three are focused on differentiating between the types of processes – different kinds of waves - that affect acceleration, transport, precipitation and loss of radiation belt particles. Two more objectives seek to understand the effects of the ring current and other geomagnetic storm phenomena on radiation electrons and ions, and how and why the ring current and associated phenomena vary during geomagnetic storms. By looking at the electric and magnetic field wave data and comparing with particle measurements from the other RBSP instruments, the EMFISIS team will work to understand the physics of how waves add and subtract energy from particles that make up the radiation belts. By looking at the DC MAG data, the EMFISIS team will identify changes in the ring current and study how such changes affect a wide range of particle and wave physics in the radiation belts.

Above: Artist's rendering showing EMFISIS booms deployed on the RBSP spacecraft.

Electric Field and Waves Suite (EFW)

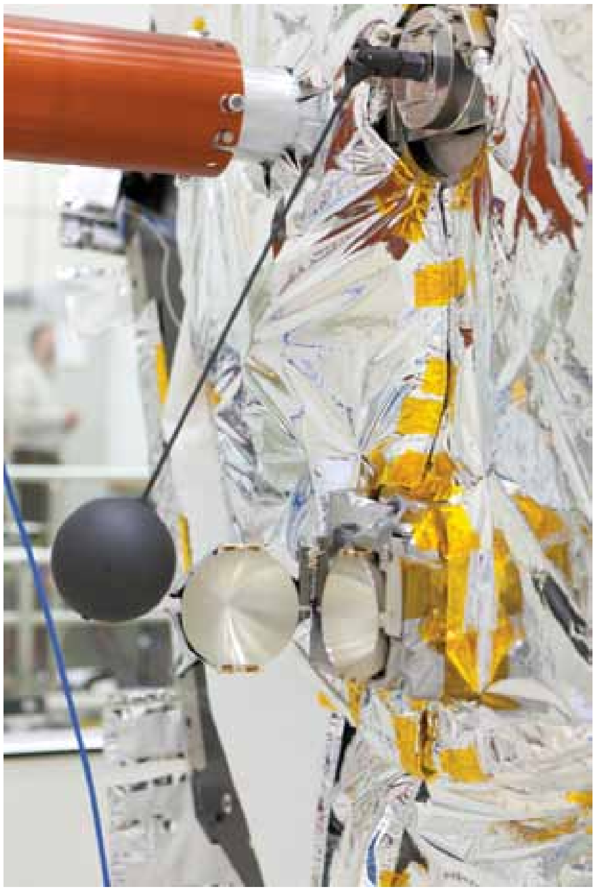
The Electric Field and Waves Suite (EFW) investigation will have one of the most recognizable features of the RBSP spacecraft: EFW's six electric field (E-field) antennae are prominent and critical pieces of detection equipment for measuring the electric fields that shape and change the particles within the radiation belts. EFW's two longest antennae extend 50 meters from each of two opposite sides (spin-plane) of the spacecraft, while their slightly shorter counterparts, mounted 90 degrees from the longer antenna, measure 40 meters in length. All four of these antenna are no thicker than coat-hanger wire, and are extended very slowly over a period of two weeks from reels that resemble those mounted on fishing rods (the slow extension is to maintain spacecraft stability). Along with two other telescoping 6-meter boom (extendable to 7 meters; for a tip-to-tip length of approximately 15 meters when the spacecraft is included) extending from the center (spin-axis) of RBSP, these six antenna will provide the most precise measurements of the electric fields ever made of the Earth's inner magnetosphere.





Above left: The four Electric Field and Waves Suite (EFW) spin-plane booms; right, an installed boom on spacecraft B (red square with centered aluminum-color circle, just right of center).

Above: The EFW axial boom.



Above: The top sphere and antenna from the EFW axial boom of spacecraft A.

At the end of each of the six antennas is a sphere about the size of a baseball. By examining the different strengths of electric fields and waves measured by each sphere as it passes through different areas of the radiation belts—and measured again by the second RBSP spacecraft—researchers will be able to detect and track changes in electric forces across the entire region. This data will allow scientists to understand how the highly charged particles in the radiation belts are accelerated, scattered, and transported.

Above: Artist's rendering of an RBSP spacecraft in orbit with all EFW booms deployed.

Radiation Belt Storm Probes Ion Composition Experiment (RBSPICE)

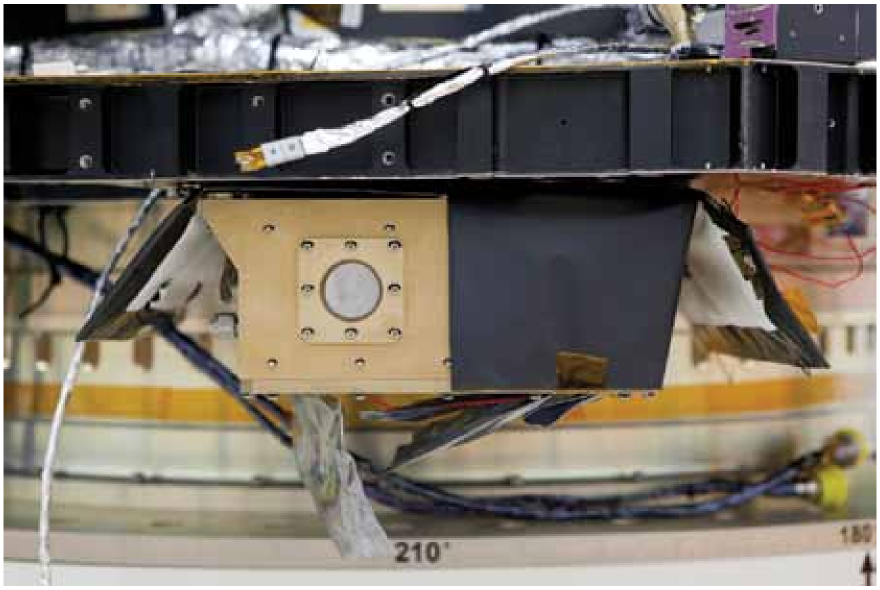
Above: The Radiation Belt Storm Probes Ion Composition Experiment (RBSPICE) installed on spacecraft B.

The Radiation Belt Storm Probes Ion Composition Experiment (RBSPICE) will, for the first time, provide researchers with an accurate measurement of plasma pressure distribution in the storm-time ring current around the Earth, providing a clearer understanding of how the ring current, the large electric current that encircles the Earth, behaves. It will also determine how the ring current contributes to geomagnetic storm effects on the radiation belts, which will help develop predictive models for belt behavior that will be used to ensure the safety of space-based technologies.

Electrons and ions captured by the magnetosphere encircle the Earth creating an electric current known as the ring current. It flows clockwise around the equator when viewed from the north. The ring current is affected, sometimes dramatically, by solar storms. This is known as storm-time ring current. RBSPICE will allow scientists to understand the effects of the ring current and other solar storm phenomena on radiation belt electrons and ions, as well as reveal the unknown processes that affect how and why the ring current (and associated phenomena) vary during geomagnetic storms. It will also show how the geomagnetic storm environment supplies and supports the acceleration and loss processes involved in creating and sustaining hazardous radiation particle populations.

The RBSPICE instrument is a time-of-flight versus energy spectrometer, the most prominent feature of which is the sensor known as the “puck” (because of its resemblance to a hockey puck). RBSPICE measures medium energy protons, electrons, and ions (H+, He+, and O+) as functions of energy and angle, and is capable of measuring the full range of expected ring current energies, intensities, and ion compositions from quiet conditions to extreme events, with a factor of ten margin against intensity saturation. There is full pitch angle coverage with a 22.5 degree angular resolution sufficient to identify free energy in particle distributions.

Relativistic Proton Spectrometer (RPS)



Above: The Relativistic Proton Spectrometer (RPS) instrument installed on spacecraft A.

The Relativistic Proton Spectrometer (RPS) is designed to study a specific type of proton in the inner Van Allen belt that is known to be able to harm satellites and astronauts operating in that region. By learning more about these protons, scientists will eventually be able to provide new methods and baselines for spacecraft designs that will result in more robust, durable, and hardened satellites that can survive the radiation belts. RPS will also seek to answer specific scientific questions about the inner belt: How do solar energetic particle (SEP) events, large magnetic storms, and interplanetary shocks and “sudden commencements” modify the inner belt? What, in addition to cosmic ray albedo neutron decay (CRAND) – caused by cosmic rays striking the atmosphere, generating neutrons there, which then convert to protons on their way back out to space – determines the steady-state inner belt? And how does the inner belt decay during geomagnetic quiet time? RPS will measure protons with energies from 50 megaelectron volts (MeV) to 2 gigaelectron volts (GeV). Expressed as a temperature, these energies correspond, respectively, to 500 billion degrees centigrade (5 x 1011 degrees) and twenty thousand billion degrees (2 x 1013 degrees). Presently, the intensity of inner belt trapped protons with energies beyond about 150 MeV is not well known, and it is thought to be underestimated in existing models used for spacecraft design. Such protons are known to pose a number of radiation hazards to astronauts and spacecraft, including total ionizing dose, displacement damage, single event effects, and nuclear activation.

Data and research from RPS will support development of a new NASA standard radiation model for spacecraft design, known as AP-9 (protons) and AE-9 (electrons); these will replace the older AE-8 and AP-8 models. NASA, the National Reconnaissance Office (NRO), NASA, the Air Force Research Laboratory (AFRL), the Aerospace Corporation, Los Alamos National Laboratory (LANL) and the Naval Research Laboratory (NRL) will develop and test these new models using RBSP data in general and RPS data specifically.

What Is Space Weather?

In much the same way that Earth experiences weather – clear skies, winds and storms – an analogous type of weather also occurs in space above and around our planet. This is called "space weather," and in much the same way the sun affects atmospheric weather on Earth, our star is responsible for disturbances in Earth's space environment.

The sun emits a continuous but varying streams of plasma (ionized gas) called the solar wind; periodically, the sun also ejects billions of tons of matter into space, in what are called coronal mass ejections. These immense clouds of matter, and other strong variations in the solar wind, when directed towards Earth, can cause large magnetic storms in the magnetosphere and the upper atmosphere. Those storms can cause problems for modern technologies both in space and on Earth.

The term space weather generally refers to conditions on the sun and in the solar wind, Earth space environment or magnetosphere, ionosphere, and upper atmosphere (exosphere, thermosphere, and mesosphere) that can influence the performance and reliability of space-borne and ground-based technological systems and can endanger human life or health.

Sources of Space Weather

- Coronal Mass Ejections: A Coronal Mass Ejection (CME) occurs when a prominence suspended above the surface of the sun erupts and sends millions of tons of material into space. This cloud of charged particles is generally confined within a magnetic field (like a magnetic bubble), expanding and traveling out through the solar system at speeds from about 200 km/s up to a staggering 2,000 km/s. When directed toward Earth, a CME typically arrives 2-3 days after eruption but in exceptional cases can arrive in less than 24 hours.

- Solar Flares: A solar flare is a bright flash of X-rays seen during an energetic explosion in an active region of the sun. It's usually seen as a large burst of X-rays, but may also have a coincident bright flash of white light. A flare lasts a matter of minutes but releases an immense amount of energy. During solar flares the sun can be 1,000 times brighter in X-rays than usual.

- Corotating Interaction Regions (CIR). The solar wind can be highly structured because of structure within the sun's upper atmosphere that generates and releases the solar wind. Such structures can be in the form of continuous and interacting streams that sweep periodically across Earth's orbit. The variations in the solar wind parameters within these streams can cause geomagnetic disturbances within Earth's space environment.

- Geomagnetic Storms: Earth's magnetosphere is a bubble created around us by our magnetic field, which protects us from most of the particles the sun throws at us. When a CME or high-speed stream arrives at Earth, it buffets the magnetosphere. High pressure discontinuities or and interplanetary shock waves can penetrate deeply and strongly affect the deep interior of Earth's magnetosphere. There are also other modes of interaction. For example, if the arriving solar magnetic field is directed southward, it interacts strongly with Earth's oppositely oriented magnetic field. As a result, Earth's magnetic field is peeled open like an onion, allowing energetic solar wind particles to stream down the field lines to hit the atmosphere over the poles. At Earth's surface, a magnetic storm is seen as a rapid drop in Earth's magnetic field strength (typically a drop of 30 to 500 nT in 1-2 hours). This decrease lasts about 6 to 12 hours, after which the magnetic field gradually recovers over a period of several days.

RBSP’s Space Weather Broadcast

NASA’s RBSP mission is partnering with an international network of contributed ground stations around the world to provide the first real-time monitoring of the dynamic Van Allen radiation belts above Earth’s atmosphere. These belts are regions where ‘space weather’ endangers both astronauts and spacecraft.

With the launch of the twin RBSP spacecraft, researchers will have two new scientific resources for resolving longstanding mysteries concerning the radiation belts and improving our ability to predict their behaviors. In addition, for the very first time, RBSP will allow scientists and engineers to receive, study, and respond to measurements within the radiation belts in almost near-real time. When conditions in the radiation belts become severe and dangerous, we will know about it almost as it happens, allowing mission operators to interpret anomalous behavior and take mitigating actions.

As the newest addition to NASA’s Heliophysics System Observatory, and the only one targeting Earth’s radiation belts, the two RBSP spacecraft will constantly broadcast data from their identical sets of five instrument suites, pausing only to deliver their 2.5-hour-per-day main science data transmission. Thanks to the development of partnerships with nations from across the globe, scientists will be able to acquire and study RBSP’s space weather broadcast data around the clock.

This new capability is implemented by having each of the spacecraft continuously broadcast a subset of collected scientific measurements about 90 percent of the time. These space weather broadcasts are received by contributed ground stations around the world, owned by RBSP partners. The data from these ground stations is automatically collected in near-real time, processed centrally at the RBSP Science Gateway located at the Johns Hopkins University Applied Physics Laboratory, put online for the world to access, and summarized with data displays that provide “at a glance” visualization – all within about 12 minutes.

To learn more about RBSP’s space weather data, and to view and explore the data as it is collected, visit the RBSP Science Gateway at http://athena.jhuapl.edu/.

The first partner organization to provide a ground station for RBSP’s Space Weather Broadcast is the Korea Astronomy and Space Science Institute (KASI).

RBSP / Atlas V 401 Expanded View

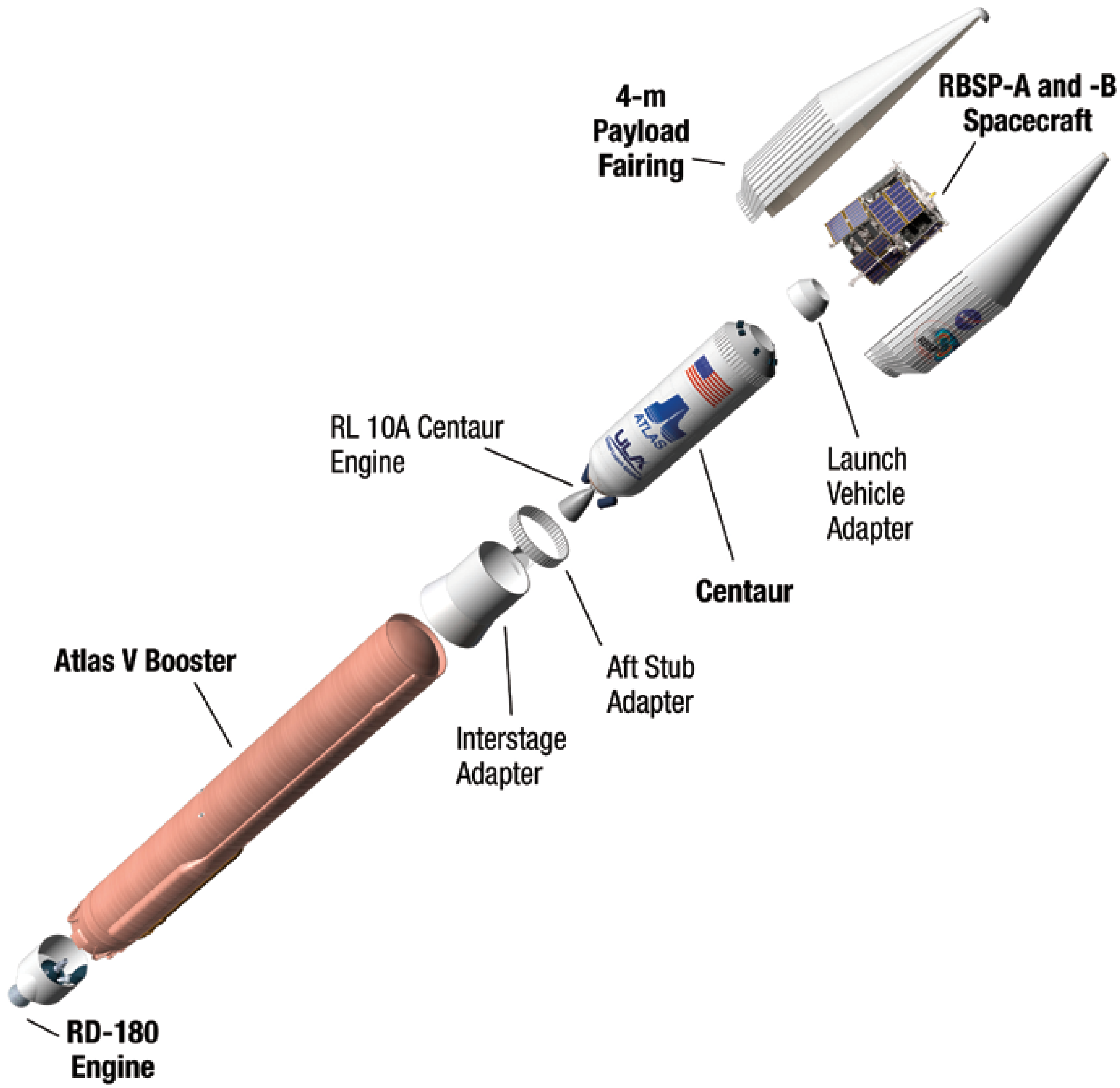


Image courtesy of ULA

NASA's Living With a Star Program

The goal of NASA's Living With a Star (LWS) Program is to provide the scientific understanding needed to effectively address those aspects of the Sun and space environment that most directly affect life and society. The ultimate goal is to develop an understanding that will allow for capability to predict space weather conditions at Earth and in the interplanetary medium.

The first LWS mission is the Solar Dynamics Observatory (SDO), which was launched early in 2010. This mission observes how the Sun's magnetic field is generated and structured and stored magnetic energy is converted and released into the heliosphere in the form of solar wind, energetic particles, and variations in the solar irradiance. The second LWS mission will be the Radiation Belt Storm Probes (RBSP). The twin RBSP spacecraft will determine how charged particles in space near the Earth are accelerated to hazardous energies that affect satellites, astronaut safety, and high-altitude aircraft. Concurrently with RBSP, the Balloon Array for Radiation-belt Relativistic Electron Losses (BARREL) will measure the high-energy particle precipitation from the radiation belts into our Earth's atmosphere. RBSP will launch in 2012.

Following RBSP are the Solar Probe Plus mission and Solar Orbiter Collaboration. Solar Probe Plus is mankind's first mission to a star and will travel into one of the last unexplored regions of our solar system, the Sun's corona. Solar Orbiter is a Sun-observing satellite under study as a collaborative mission with the European Space Agency. Solar Orbiter will be the first satellite to provide close-up views of the Sun's polar regions, which are very difficult to see from Earth.

LWS Web Sites

Missions:

RBSP	http://nasa.gov/rbsp
SDO	http://sdo.gsfc.nasa.gov/
BARREL	http://nasascience.nasa.gov/missions/barrel-1
Solar Orbiter	http://nasascience.nasa.gov/missions/solar-orbiter
Solar Probe Plus	http://nasascience.nasa.gov/missions/solar-probe

Other Program Elements:

LWS Targeted Research and Technology Program	http://lwstrt.gsfc.nasa.gov/
Space Environment Testbed Flight Opportunity	http://lws-set.gsfc.nasa.gov/
International Living With a Star Program	http://ilwsonline.org/

The goal of Living With a Star emphasizes the science necessary to understand those aspects of LWS missions target the linkages across the interconnected system with an ultimate goal of enabling a predictive understanding.

NASA's Launch Services Program

NASA turns to the engineers and analysts in its Launch Services Program to send robotic spacecraft on their way for some of the most exciting and notable missions in the agency's history.

The Launch Services Program, known as LSP, is based at NASA's Kennedy Space Center in Florida and boasts a roster of engineers and technicians who specialize in all aspects of rocketry and spacecraft integration. LSP selects the appropriate launcher for a mission's spacecraft, in this case the United Launch Alliance Atlas V for the Radiation Belt Storm Probes, or RBSP. Sometimes, this selection process takes place years before the first launch opportunity. The program then provides oversight as the designs of the rocket and mission are integrated with each other.

As liftoff nears, teams oversee the launch vehicle's engineering and manufacture and its integration with the spacecraft. LSP conducts the countdowns for NASA's scientific missions and provides additional quality assurance along with other controls to ensure a successful mission.

Working with commercial rocket builders, planners have a number of rocket models to choose from, ranging from the small, air-launched Orbital Sciences Pegasus to the workhorse Delta II rocket from the United Launch Alliance, or ULA, to the powerhouse Altas V, also from ULA. The catalog is growing, too, with the addition of the SpaceX Falcon 9 and Orbital Sciences Antares rockets.

LSP moved its operations to Kennedy in 1998, becoming the first program based at the nation's premiere launch site. The 14 years since then have seen orbiters, landers and rovers to Mars, huge observation spacecraft to Jupiter and the New Horizons mission launched to Pluto and the Kuiper Belt, two astronomical locations that have never been seen up-close before.

Because some spacecraft need to fly in a different kind of orbit, LSP operates several launch centers around the world. Cape Canaveral Air Force Station in Florida is adjacent to Kennedy Space Center and hosts launches to place spacecraft in orbits that remain close to the equator.

The LSP launch team goes to Vandenberg AFB in California to run launches that require spacecraft to fly around the world in a north-to-south orbit, known as a polar orbit. LSP also conducts launches from Kwajalein in the Marshall Islands, Kodiak Island, Alaska, and NASA's Wallops Flight Facility on Virginia's eastern Shore.

To learn more about LSP, rockets and NASA mission, visit:
http://www.nasa.gov/centers/kennedy/launchingrockets/index.html

RBSP Program/Project Management

NASA's Radiation Belt Storm Probes (RBSP) will undertake a two-year mission to help scientists understand the sun's influence on the Earth and near-Earth space by studying the planet's radiation belts on various scales of space and time. As the second mission of NASA's Living With a Star (LWS) Program, RBSP will investigate the physical mechanisms that take place within the belts. The twin spacecraft will study how energized particles and electric and magnetic fields and waves in the radiation belts are affected by energy from the sun and other forces that interacts with Earth. RBSP is managed for NASA by the Johns Hopkins University Applied Physics Laboratory (APL) in Laurel, Md.

Director, Heliophysics Division
Barbara Giles
NASA Headquarters
Barbara.Giles@nasa.gov

LWS Program Scientist
Madhulika Guhathakurta
NASA Headquarters
Madhulika.Guhathakurta@nasa.gov

LWS Program Manager
Nicholas G. Chrissotimos
NASA Goddard Space Flight Center
Nicholas.G.Chrissotimos@nasa.gov

RBSP Mission Scientist
David Sibeck
NASA Goddard Space Flight Center
David.G.Sibeck@nasa.gov

RBSP Deputy Project Scientist
Nicola Fox
Johns Hopkins APL
Nicola.Fox@jhuapl.edu

RBSP Program Executive
Dana Brewer
NASA Headquarters
Dana.A.Brewer@nasa.gov

RBSP Program Scientist
Mona Kessel
Science Mission Directorate
Mona.Kessel@nasa.gov

RBSP Project Manager
Richard Fitzgerald
Johns Hopkins APL
Richard.Fitzgerald@jhuapl.edu

RBSP Project Scientist
Barry Mauk
Johns Hopkins APL
Barry.Mauk@jhuapl.edu

RBSP Education and Outreach Lead
Dawn Turney
Johns Hopkins APL
Dawn.Turney@jhuapl.edu

Public Affairs Contacts
Dwayne Brown • NASA Headquarters
Dwayne.C.Brown@nasa.gov

Jennifer Rumburg • NASA Headquarters
Jennifer.Rumburg@nasa.gov

Geoff Brown • Johns Hopkins APL
Geoffrey.Brown@jhuapl.edu

Susan Hendrix • NASA Goddard
Susan.M.Hendrix@nasa.gov

RBSP Web Sites for More Information
http://www.nasa.gov/rbsp
http://www.rbsp.jhuapl.edu

RBSP Science Instrument Web Sites
ECT: http://rbsp-ect.sr.unh.edu/
EMFISIS: http://www-pw.physics.uiowa.edu/rbsp/
EFW: http://ham.space.umn.edu/current.html
RBSPICE: http://rbspice.ftecs.com/
RPS: http://rbsp.jhuapl.edu/spacecraft/instruments/instruments_rps.php