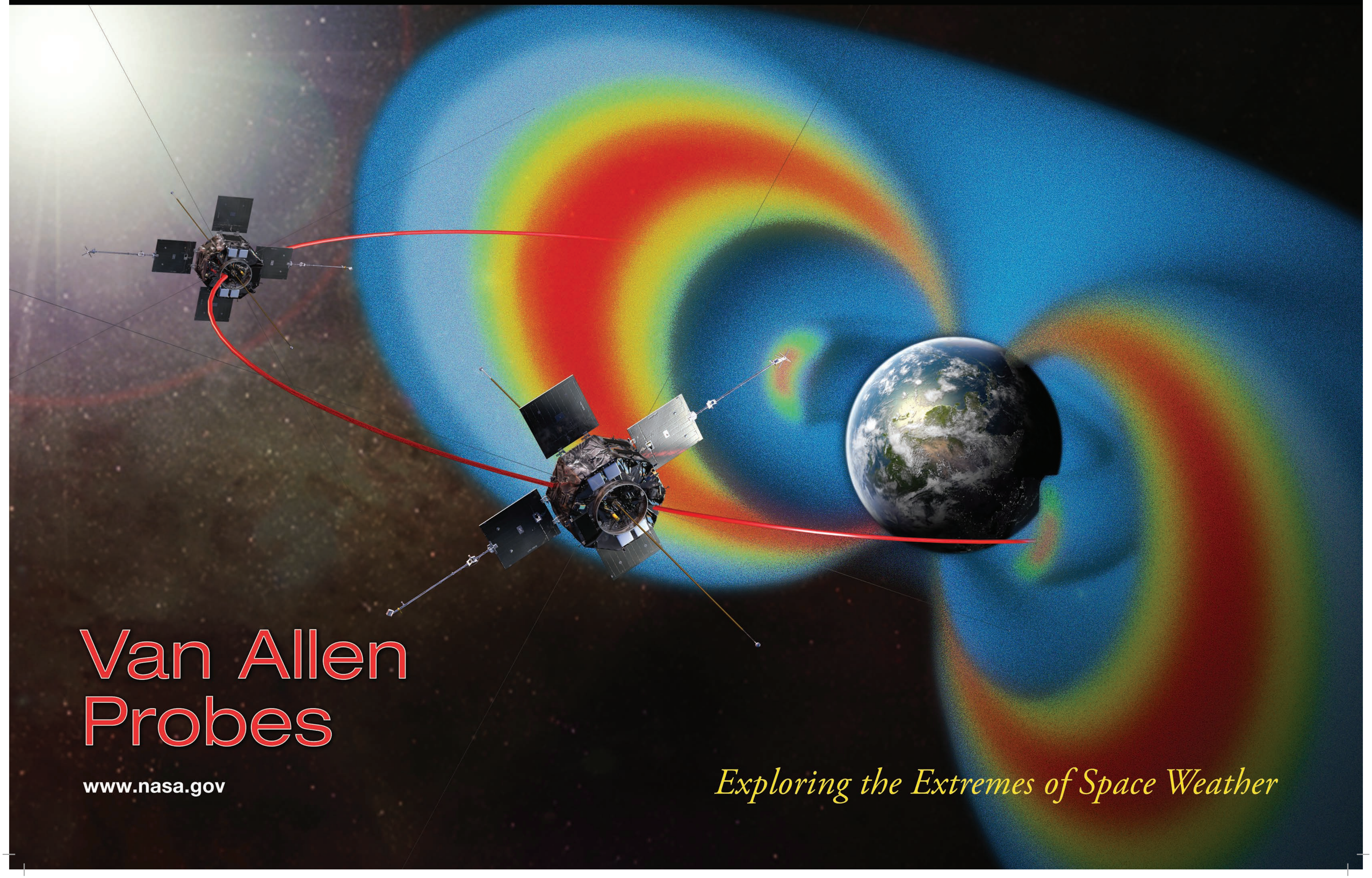
National Aeronautics and Space Administration



Van Allen Probes

www.nasa.gov

Exploring the Extremes of Space Weather

Van Allen Probes—Exploring th

About the Van Allen Probes Mission

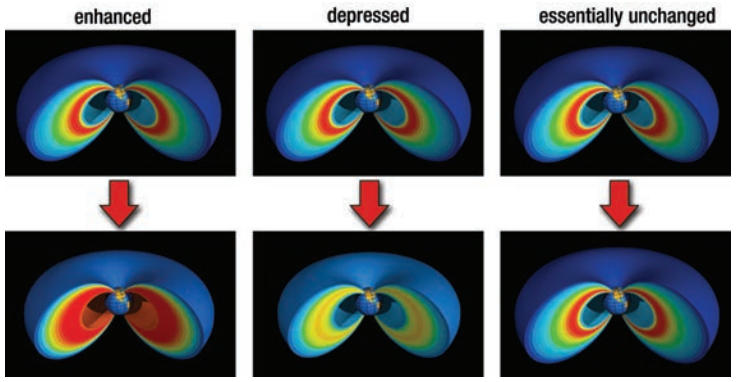
To help us understand how Earth responds to changes in the sun's energy and how that response affects life and society, NASA launched the Van Allen Probes August 30, 2012. These twin spacecraft will investigate this extreme region of space for a minimum of two years, searching for answers to critical questions about the behavior of the Van Allen radiation belts. The spacecraft will chase each other in a common orbit, investigating the storms caused by our sun and gathering data to solve the mysteries that are critical to our modern way of life. The ability to predict the behaviors of the radiation belts will enable engineers and space weather forecasters to better protect our astronauts working in this region as well as our satellite investments that we depend on for communication, defense, shipping, air and ground navigation, and much more.

What is radiation?

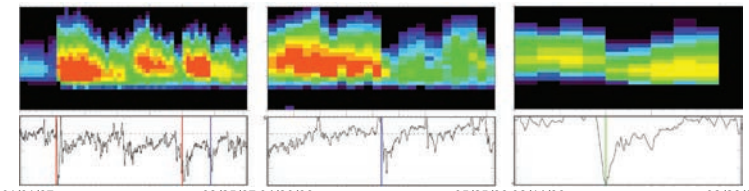
You may have heard the term radiation used in different ways, sometimes in relation to medicine, or the sun, or even heat. Sometimes it refers to electromagnetic waves of energy such as X-rays or gamma rays, and other times it refers to fast-moving particles. When we talk about radiation in the Van Allen belts, we are referring to electrically charged particles such as protons and electrons that move close to the speed of light, about 186,000 miles a second or about 700 million miles an hour. The faster something moves, the more energy it has. Even tiny particles like electrons that are moving close to the speed of light have so much energy that they can do serious damage to any matter that they hit. Challenge question: Imagine if it were possible for you to ride your bike at a "relativistic" speed (moving close to the speed of light). How fast could you travel from Earth to the moon? (Hint: First you need to research the distance to the moon.)

What are the Van Allen radiation belts and why do we want to study them?

The Van Allen radiation belts are two donut-shaped regions encircling Earth where high-energy particles are trapped by Earth's magnetic field. Sometimes after a solar storm, the number of particles can increase dramatically, and their speeds can become close to the speed of light. This can be extremely dangerous for our technology in this region as well as for astronauts working there. Other times after similar space weather events, the particles decrease in number and speed, and sometimes conditions seem to stay the same. The data on the left show three very similar solar storms that all produced energies of 1.2–2.4 MeV. After the first storm in 1997, the radiation became more intense; the second graph shows data taken in 1999, when the radiation belts decreased in intensity; and the third graph shows that after a storm in 1998, the radiation remained pretty much the same. The pictures on the right show an artist's interpretation of the radiation belts during such events.



Images courtesy of G. Reeves, Los Alamos National Laboratory



Images courtesy of G. Reeves, Los Alamos National Laboratory
Red and orange indicate higher particle intensity. Blue and green indicate lower particle intensity.

Van Allen Probes will explore this mysterious space weather, which can impact our way of life as we become increasingly dependent on space-based infrastructure. Extreme space weather can disable satellites, cause power grid failures, and disrupt GPS services. What we find out will be used by engineers to design radiation-hardened spacecraft and satellites and will be used by forecasters to warn astronauts and spacecraft operators of hazardous conditions. Earth's radiation belts also provide a perfect laboratory in which to understand many other places in the universe that are known to have similar processes but are farther away and harder to study. We have a place in Earth's own backyard that can provide answers to some of the mysteries of our galaxy and beyond.

What are the main questions we want to answer?

The Van Allen Probes mission will answer three overarching science questions:

- What causes the radiation belts to become enhanced (increasing in particle density and energy)?
- What causes the radiation belts to decrease in particles and energy, and how are the particles lost?
- There is an electric current of slower-moving charged particles that moves through the radiation belts called the ring current. How does this affect the radiation belts, and how do other geomagnetic processes (changes in Earth's magnetic field) affect radiation belt behavior?

Why are they named Van Allen radiation belts?

Dr. James Van Allen and his students at The University of Iowa were the first to detect the inner and outer radiation belts surrounding Earth in 1958 using instruments onboard Explorer 1. This was one of the first space age

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discoveries. Many of Dr. Van Allen's students are still working in the field, carrying on and building on that first discovery as well as teaching and mentoring new scientists in the field of heliophysics (the exploration of the sun and its impacts on Earth and the planets of the solar system). To read more about Dr. Van Allen, see ***http://vanallenprobes.jhuapl.edu/science/overview.php***.

Why does the Van Allen Probes mission need two identical spacecraft?

Only with identical instruments on two spacecraft, with one following after the other in nearly the same path, can we measure changes in the radiation belts over both space and time. For example, imagine that a probe detects an increase in radiation at point A. A minute later, it flies through point B and detects a similar increase in radiation. Without a second probe, it wouldn't be possible to determine whether the change was happening across the entire area or whether the location of the increased radiation had shifted from point A to B.

Are the radiation belts actually brightly colored like they are in pictures?

Often scientists use colors to depict conditions in a way that appears different from the way an object or space actually appears visually. They use these models or animations so that people can easily gain information. In reality, if you were to stand in the middle of the radiation belts, you wouldn't be able to see them at all! In the picture on the front of this poster, red indicates areas where there are a lot of high-energy particles, yellow indicates areas that are a little less intense, and green and blue indicate areas with the least amount of radiation.

If the particles are invisible, how do we know they are there?

Even when we can't see something, we can detect it's there by using other senses or tools. Think about a time you have investigated magnetism. You can't see a magnetic force, but you can detect it when you use a tool such as a magnet or a compass. Each probe will carry five suites of instruments onboard that will measure particle numbers, type, speed, direction, and energy, as well as electric and magnetic fields and waves. The instrument suites are called: Energetic Particle, Composition, and Thermal Plasma Suite (ECT), Electric and Magnetic Field Instrument Suite and Integrated Science (EMFISIS), Electric Field and Waves Suite (EFW), Radiation Belt Storm Probes Ion Composition Experiment (RBSPICE), and Relativistic Proton Spectrometer (RPS). By putting together all the data that each of the instruments gather, we will be able to better understand this mysterious region.

Teamwork

Teamwork is important! Scientists and engineers from many universities and organizations have come together as a team to make this mission a success. The Johns Hopkins University Applied Physics Laboratory built and operates Van Allen Probes for NASA's Living With a Star Program, which is managed by NASA Goddard Space Flight Center. The instruments were provided by teams of people from all over the United States that are managed by the University of New Hampshire, The University of Iowa, the University of Minnesota, the New Jersey Institute of Technology, and the National Reconnaissance Office. More information can be found about the spacecraft, the instruments, and the teams of people that work on the mission on the websites listed in the resource toolbox.

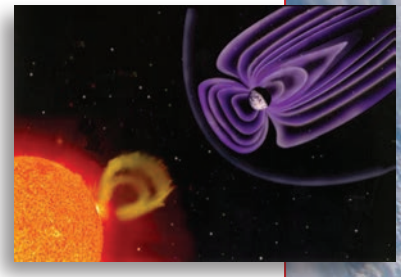
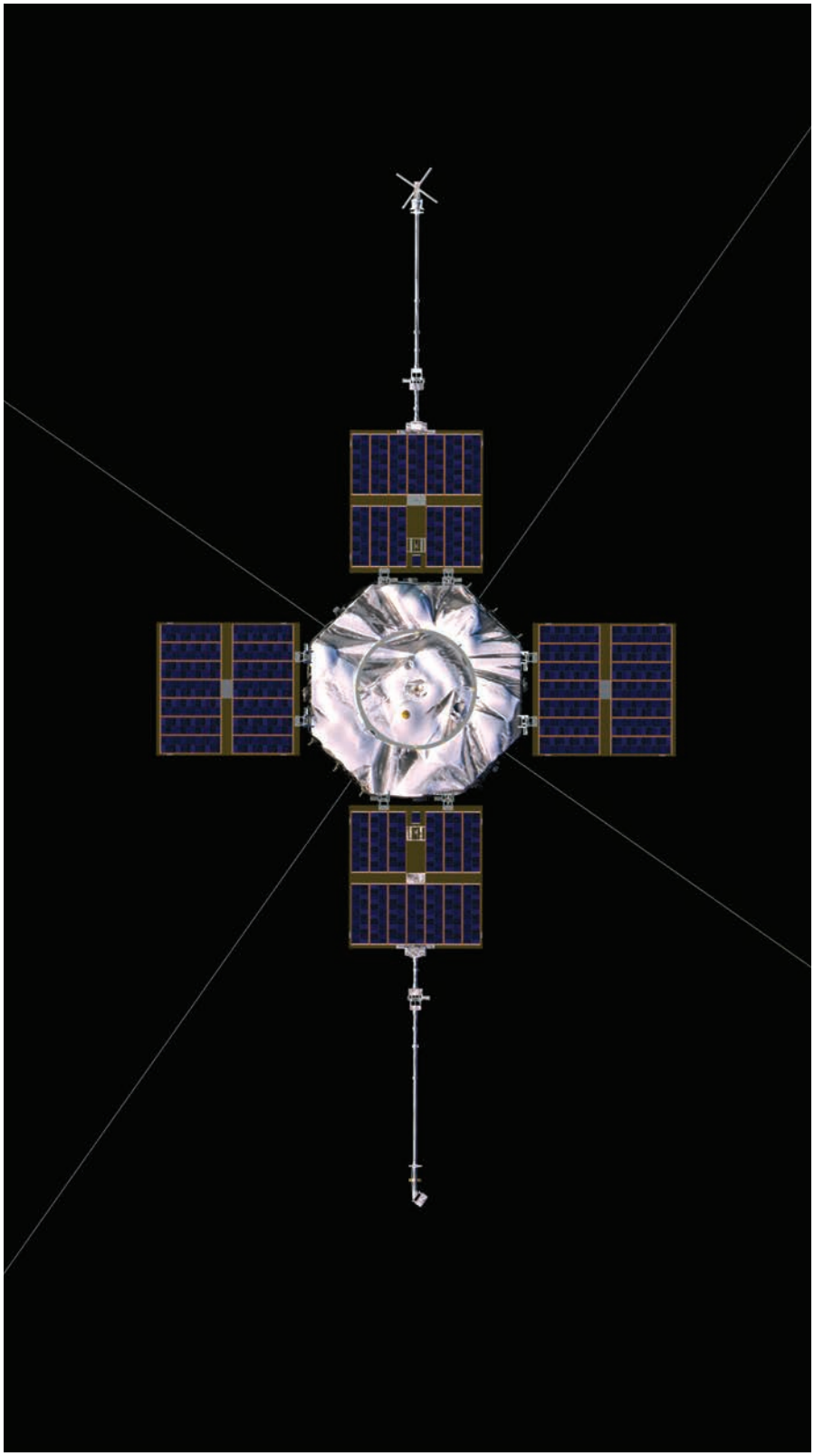


Image credit: NASA. The source of space weather, our dynamic sun, shown with a coronal mass ejection that will interact with the terrestrial magnetosphere, producing geospace storms.

Image credit: JHU/APL. The identical Van Allen Probes will follow similar orbits that will take them through both the inner and outer radiation belts. The highly elliptical orbits range from a minimum altitude of approximately 373 miles (600 kilometers) to a maximum altitude of approximately 23,000 miles (37,000 kilometers).

Electricity from Sunlight: The Van Allen Probes' Solar Panels

NASA's Van Allen Probes were launched in 2012. The figure to the right shows the octagonal spacecraft body and the location of the surrounding four solar panel "wings" that provide power to the spacecraft instruments. The small blue rectangles within each of the four solar panels show the locations of the solar cells used to power the spacecraft. As the spacecraft orbits Earth, the four solar panels continuously face the sun to provide constant power.



Problem 1:

Each of the four solar panels measures 94 cm × 98 cm. What is the area of each solar panel in square centimeters?

Problem 2:

What is the total area of the four solar panels to the nearest tenth of a square meter?

Problem 3:

The amount of electrical power generated by a solar panel is 0.03 W/cm². What is the total power generated by the four solar panels on one Van Allen Probes spacecraft to the nearest hundred watts?

To see how these answers were derived, log onto: ***http://vanallenprobes.jhuapl.edu/education/teachers/mathProblems.php.***

Answer Key

Problem 1
Answer: **9,212 cm²**

Problem 2
Answer: **3.7 m²**

Problem 3
Answer: **1,100 W**

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TST-12-04097 JHU/APL

Language Arts Connection

Vocabulary Matching Game

Match the following vocabulary words, which you may have seen while reading about the Van Allen Probes mission, with their definitions. If you have trouble, the glossary on the Van Allen Probes webpage may be helpful to you: http://vanallenprobes.jhuapl.edu/education/generalInfo/glossary.php.

A. Radiation	_____ This is an adjective that describes something that can move close to a speed of 186,000 miles per second (the speed of light).
B. Density	_____ Disruptions or changes in the space environment caused by changes in solar activity.
C. Van Allen Radiation Belts	_____ How much mass there is in a given volume. Put simply, if mass is how much "stuff" there is, this is the measure of how much "stuff" is packed into a certain amount of space. (In this particular case, a measure of how many particles are in a radiation belt.)
D. Space Weather	_____ This word has various meanings, but when discussed here, it refers to electrically charged particles that move so fast that they cause damage when they hit other matter.
E. Ring Current	_____ Two donut shaped regions surrounding Earth where high-energy (i.e., fast moving), electrically charged particles are trapped by Earth's magnetic field.
F. Relativistic	_____ A current of electricity that moves in a ring-like pattern through Earth's radiation belts.
G. Geomagnetic	_____ Refers to the magnetism of Earth.

Communicating Research

An important aspect of scientists' work is telling the story of their research. Scientists need to be good writers and speakers so they can share the new exciting things they have discovered with others.

Try It: Research James Van Allen and his team at the University of Iowa, who first discovered Earth's radiation belts, and write a story about their work and about the radiation belts that were named for Van Allen. Some questions you might want to investigate are: How did Van Allen and his team discover the radiation belts? Why was their discovery exciting? Why do we want to know more about the Van Allen radiation belts? Have there been other people who researched the sun's influence on Earth and the space around it? Are there radiation belts around other planets or just ours?

Challenge: How many new vocabulary words can you use correctly in your story?

Bonus: BE BRAVE! Ask your teacher if you can tell your class the story of what you discovered so that you, like a scientist, can practice your oral communication skills!

To get started, check out: *http://vanallenprobes.jhuapl.edu*.

Toolbox of Resources

Van Allen Probes videos, animations, resources, and more:	***http://vanallenprobes.jhuapl.edu***
Hear about Van Allen Probes and what it's like to work on space missions:	***http://vanallenprobes.jhuapl.edu/mission/conversation/overview/index.php***
Living With a Star Program:	***http://lws.gsfc.nasa.gov***
Space Math Problems and Solutions at Space Math @ NASA:	***http://spacemath.gsfc.nasa.gov***
Van Allen Probes instrument descriptions:	***http://vanallenprobes.jhuapl.edu/spacecraft/instruments/index.php***
Space Weather Center; student-friendly activities, games, and explanations in English and Spanish:	***http://www.spaceweathercenter.org/***
Kid-friendly description of sun–Earth connection science, including magnetic fields, space weather, auroras, and more:	***http://spaceplace.nasa.gov/spaceweather/en/***

Answer Key

F, D, B, A, C, E, G