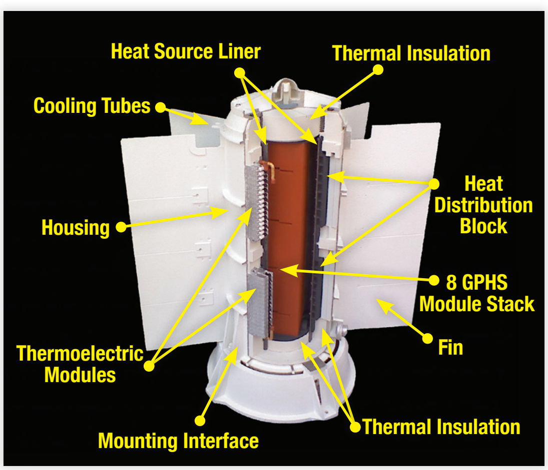
National Aeronautics and Space Administration

NASAfacts

Multi-Mission Radioisotope Thermoelectric Generator (MMRTG)

Space exploration missions require safe, reliable, long-lived power systems to provide electricity and heat to spacecraft and their science instruments. A flight-proven capable source of power is the Radioisotope Thermoelectric Generator (RTG)–essentially a nuclear battery that reliably converts heat into electricity.

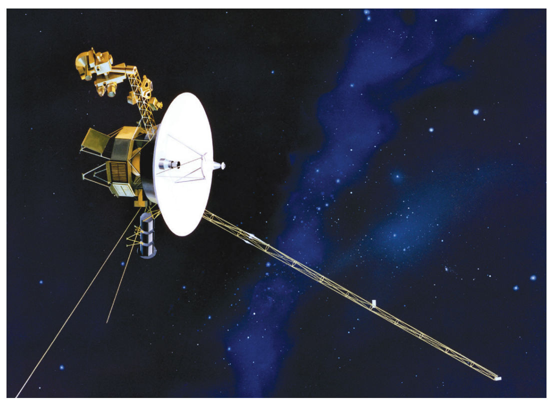
NASA and the Department of Energy (DOE) have developed a new generation of such power systems that could be used for a variety of space missions. The newest RTG, called a Multi-Mission Radioisotope Thermoelectric Generator (MMRTG), has been designed to operate on Mars and in the vacuum of space. The MMRTG has a flexible modular design capable of meeting the needs of a wide variety of missions, as it generates electrical power in smaller increments than previous generations of RTGs, about 110 watts at launch. The design goals for the MMRTG included optimizing power levels over a minimum lifetime of 14 years and ensuring a high degree of safety.



MMRTG Model

History of RTGs in Space

First launched into Earth orbit in 1961, RTGs have flown on 27 space missions involving 46 RTGs. RTGs have enabled NASA to explore the Solar System for four decades and counting. The Apollo missions to the moon, the Viking and Curiosity missions to Mars, and the Pioneer, Voyager, Ulysses, Galileo, Cassini and Pluto New Horizons missions to the outer Solar System all used RTGs. The RTGs for the Pioneer 10 spacecraft operated flawlessly for three decades until the spacecraft signal was finally too weak to detect in 2003. The spectacular Voyager 1 and 2 missions, operating on RTG power since launch in 1977, continue to function, with Voyager 1 just having reached interstellar space.



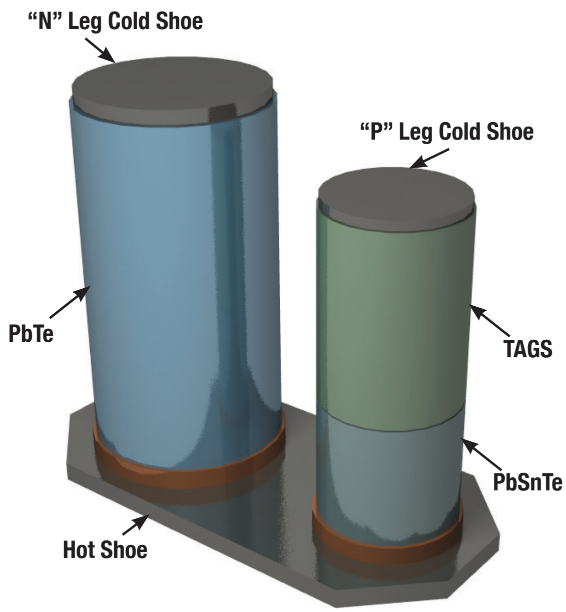
An artist impression of Voyager 1

How RTGs Work

RTGs work by converting heat from the natural decay of radioisotope materials into electricity. RTGs consist of two major elements: a heat source that contains plutonium-238 (Pu-238) and solid-state thermocouples that convert the plutonium's decay heat energy to electricity.

Conversion of heat directly into electricity is a scientific principle discovered 150 years ago by German scientist Thomas Johann Seebeck. He observed that an electric voltage is produced when two dissimilar, electrically conductive materials are joined in a closed circuit and the two junctions are kept at different temperatures. Such pairs of junctions are called thermoelectric couples (or thermocouples).

The power output from such thermocouples is a combination of the temperature of each junction and the properties of the thermoelectric materials. The thermocouples in RTGs use heat from the decay of Pu-238 to heat the hot side of the thermocouple, and the cold of space or a planetary atmosphere to produce a low temperature at the cold side.

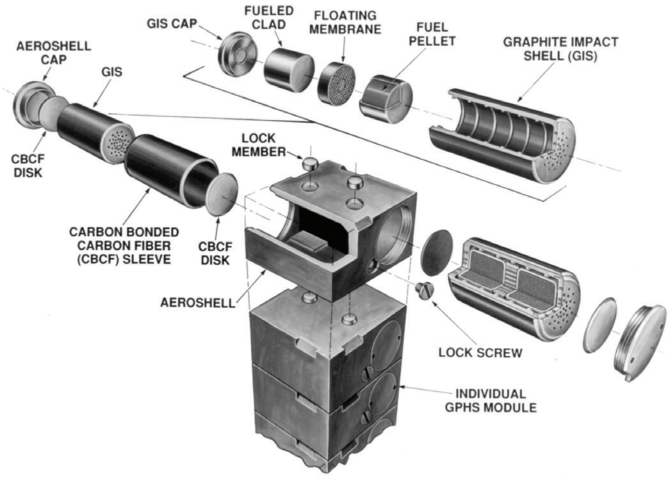


MMRTG Thermoelectric Couple

Safety and Design of RTGs

The MMRTG is designed to use a heat source composed of eight General Purpose Heat Source (GPHS) modules. These GPHS modules are the basic building block of safety for Radioisotope Power Systems. While RTGs have never been the cause of a spacecraft accident, they have been on board three space missions that failed for other reasons. In all three cases, the RTGs performed precisely as designed.

The MMRTG contains a total of 10.6 pounds (4.8 kilograms) of plutonium dioxide (including Pu-238) that initially provides approximately 2,000 watts of thermal power and 110 watts of electrical power when exposed to deep space environments. The thermoelectric materials (PbSnTe, TAGS, and PbTe) have demonstrated extended lifetime and performance capabilities, and are the same as those used for the two Viking spacecraft that landed on Mars in 1976. The MMRTG generator is about 25 inches (64 centimeters) in diameter (fin-tip to fin-tip) by 26 inches (66 centimeters) tall and weighs about 94 pounds (45 kilograms)



GPHS Module Illustration provided by DOE

Mars Science Laboratory

The first NASA mission to carry an MMRTG is the Curiosity Mars rover, which was launched in November 2011 and landed successfully on the Red Planet on August 6, 2012. Curiosity, the largest and most capable rover ever sent to another planet, has already achieved its main goal of determining that its landing site, Gale Crater, could have supported life in the ancient past.

The Curiosity rover took this self portrait on the surface of Mars, with its MMRTG power source visible at the rear.

In just its first year on Mars, Curiosity provided more than 190 gigabits of data; returned more than 36,700 full images and 35,000 thumbnail images; fired more than 75,000 laser shots to investigate the composition of numerous geologic targets; collected and analyzed sample material from two Mars rocks; and drove more than one mile (1.6 kilometers).

For more information about NASA's use of Radioisotope Power Systems, see: **rps.nasa.gov** or email *rps@nasa.gov*

Department of Energy contact:
Ryan Bechtel
(301) 903-1167
Ryan.Bechtel@nuclear.energy.gov