Space Radioisotope Power Systems

Multi-Mission Radioisotope Thermoelectric Generator

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Why are Radioisotope Thermoelectric Generators Needed in Space?

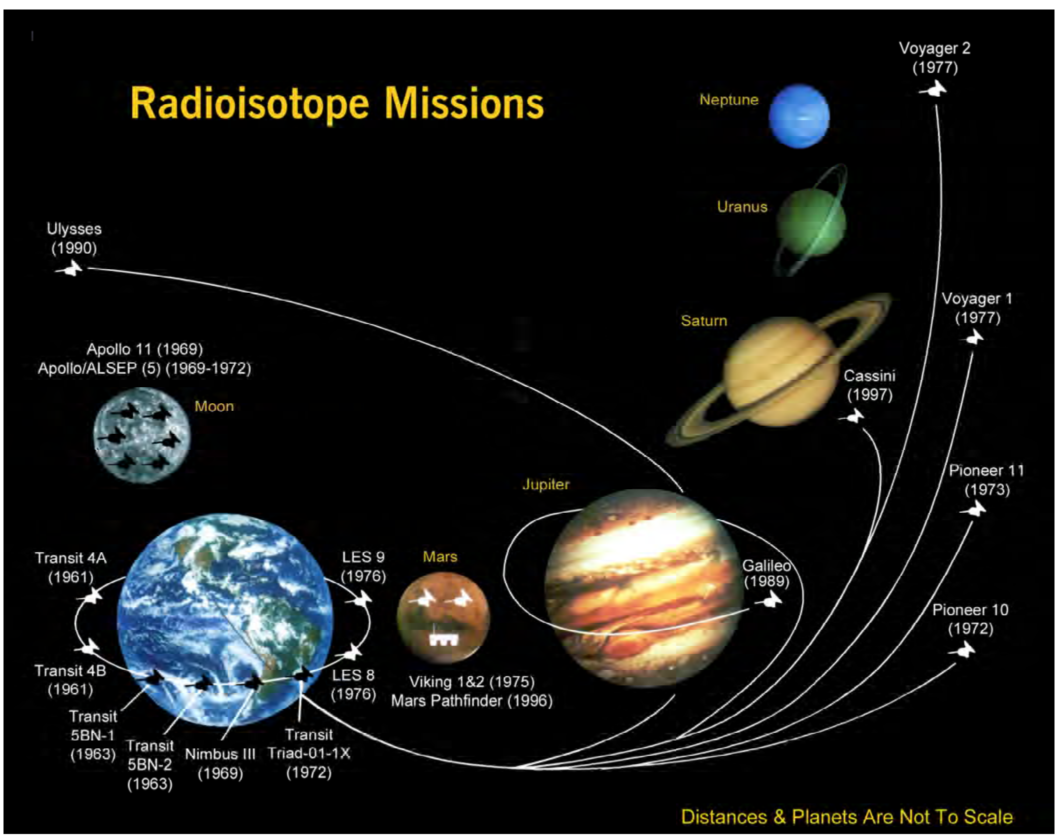
Radioisotope Thermoelectric Generators (RTGs) can provide continuous power for twenty-plus years, and have been used safely and reliably over the past 30 years in regions of space where the use of solar power is not feasible.

What is the History of RTGs in Space?

RTGs are not a new part of the U.S. space program. In fact, they have enabled the National Aeronautics and Space Administration (NASA) to explore the Solar System for many years. The Apollo missions (to the Moon), the Viking missions (to Mars), and the Pioneer, Voyager, Ulysses, Galileo, and Cassini (outer Solar System) missions all used RTGs. The RTGs for the Pioneer 10 spacecraft have operated flawlessly for three decades and continue to power the spacecraft as it travels beyond Pluto. Over the last three decades, the United States has launched 25 missions involving 44 RTGs. While RTGs have never been the cause of a spacecraft accident, they have been on board three space missions that did fail for other reasons. In all three cases, the RTGs performed as designed. Early RTGs carried smaller amounts of radioisotope material and in keeping with the safety philosophy at the time, were built to burn up at high altitude during an accidental reentry. One such reentry occurred in 1964 during the malfunction of a navigational satellite for the Navy. Later RTGs were designed to contain their plutonium in case of reentry and performed this function successfully in mission failures in 1968 (a weather satellite launch failure) and 1970 (Apollo 13).

How Do 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 dioxide and a set of solid-state thermocouples that convert the plutonium's heat energy to electricity. Conversion of heat directly into electricity is not a new principle. It was discovered 150 years ago by a German scientist named Thomas Johann Seebeck. He observed that an electric voltage is produced when two dissimilar, electrically conductive



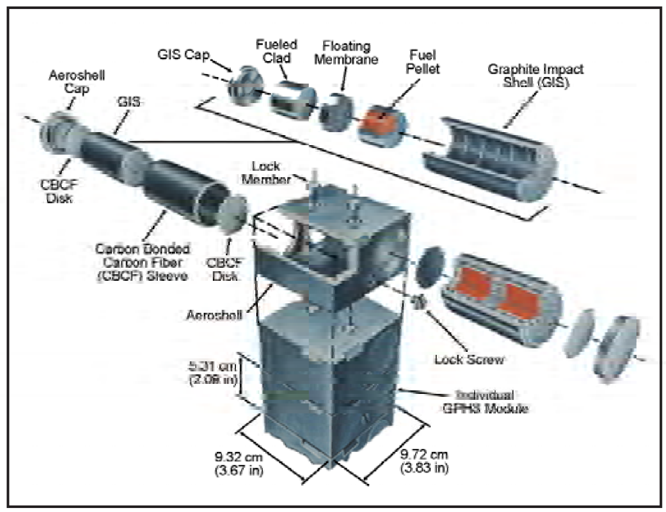
materials are joined in a closed circuit and the two junctions are kept at different temperatures. Such pairs of junctions are called thermoelectric couples (or thermocouples). The power output is a function of the temperature of each junction and thermoelectric materials properties. The thermocouples in RTGs use heat from the natural radioactive decay of plutonium-238 to heat the hot junction of the thermocouple, and use the cold of outer space to produce a low temperature at the cold junction of the thermocouple.

What are the Current Development Plans?

The need for safe, reliable, long-lived power systems for future missions includes surface exploration of planetary bodies such as Mars as well as missions in the vacuum of space beyond Earth orbit. The Department of Energy and NASA are initiating the development of a new generation of power system that could be used for a variety of missions. The new RTG, called a Multi-Mission Radioisotope Thermoelectric Generator (MMRTG), will be designed to operate on planetary bodies as well as in the vacuum of space. In addition, the new MMRTG will be designed to generate approximately 100 watts of electricity which is a more flexible modular design capable of meeting the needs of a wider variety of missions. The design goals for the MMRTG include ensuring a high degree of safety, optimizing power levels over a minimum lifetime of fourteen years, and minimizing weight. The MMRTG will use thermoelectric materials that have demonstrated extended lifetime and performance capabilities, and will be designed to use a heat source composed of eight General Purpose Heat Source (GPHS) modules. Each GPHS module with plutonium-238 dioxide will provide approximately 250 watts of thermal power.

Summary

The Department of Energy and NASA are currently planning a competitive procurement for the design, development, and qualification of MMRTGs. The intent is to develop a more flexible, modular MMRTG for potential use in a variety of NASA space exploration missions, both on planetary bodies and in the vacuum of deep space.



GPHS Module