



## *Spacecraft Power for New Horizons*

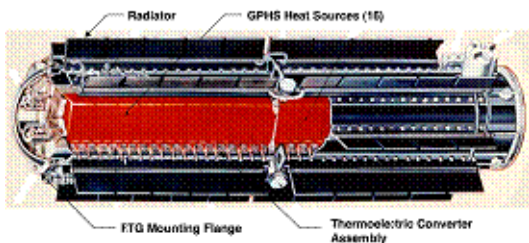


NASA's planned New Horizons mission would be the first-ever spacecraft exploration of Pluto and the Kuiper Belt. If approved, a radioisotope thermoelectric generator (RTG) will provide the electrical power to operate the New Horizons spacecraft's mechanical and electronic systems in the cold darkness of deep space. The Johns Hopkins University Applied Physics Laboratory (APL) will build the spacecraft.

New Horizons' journey is planned to take it more than 4 billion miles from Earth, where the Sun is just a bright star in the dark sky. Besides taking longer than 4 hours to reach Pluto and nearby Kuiper Belt objects, light from the Sun is 1,000 times fainter there than at Earth.

### What Are RTGs?

RTGs are compact and extraordinarily reliable spacecraft power systems.



RTGs convert the heat generated from the natural decay of the radioactive fuel into electricity. RTGs consist of two major elements: a heat source that contains plutonium dioxide in the form of ceramic pellets and a set of solid-state thermocouples that convert the plutonium's heat energy to electricity.

In 1821, Thomas Johann Seebeck discovered how to convert heat directly into electricity

using a simple and robust device. He found that an electrical current is generated when two dissimilar electrically conductive materials are connected in a closed circuit and their junctions are kept at different temperatures. Thermoelectric couples (or thermocouples) in various forms are in common use today, with proven long-term reliability and no moving parts they are well suited to the space environment.

The RTG thermocouples use heat generated by the radioactive decay of plutonium to heat the hot junction of the thermocouple, and exposure to the cold of outer space to maintain the temperature of the cold junction. The electrical output is a function of the temperature difference between the hot and cold sides of the thermocouple. A number of these thermocouples are arranged in a converter assembly and the electricity generated by the converter is then available to power the spacecraft instruments.

RTGs can provide continuous power in regions of space where the use of solar power is not feasible. Over the past 40 years, RTGs have been used safely and reliably on 25 missions, including six Apollo flights to the moon, two Pioneer spacecraft to Jupiter and Saturn, two Mars Viking landers, two Voyager missions to the outer planets, the Galileo mission to Jupiter, the Ulysses mission to the Sun's poles, and the Cassini-Huygens mission to Saturn.

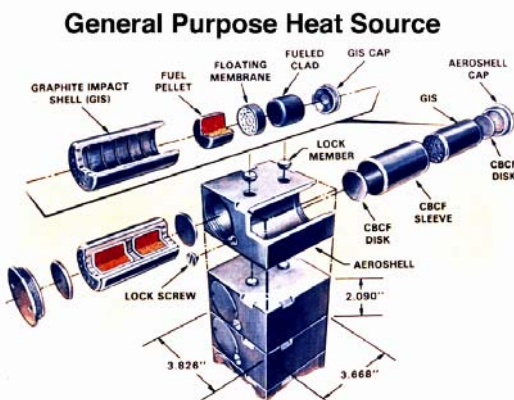
### Designed for Safety

More than 40 years have been invested in the engineering, analysis and testing of RTGs. As described below, safety features of an RTG include the use of a specific type of fuel material, a modular design and construction and the use of multiple physical barriers.

The plutonium dioxide fuel contained in RTGs is a specially formulated fire-resistant ceramic that is manufactured as pellets to reduce the possibility of fuel dispersion in a launch or reentry accident. This ceramic form resists dissolution in water and reacts little with other chemicals. If fractured, the ceramic tends to break into relatively large particles and chunks that pose fewer hazards than small, microscopic particles.

Multiple layers of protective materials, including iridium capsules and high-strength graphite blocks, protect and contain the fuel and reduce the chance of release of the plutonium dioxide. Iridium, a strong, ductile, corrosion-resistant metal with a very high melting temperature, encases each fuel pellet. Impact shells made of lightweight and highly heat-resistant graphite provide additional protection.

Each RTG contains 18 heat source modules with four plutonium dioxide pellets in each module. There are two plutonium dioxide pellets in each graphite impact shell, and two graphite impact shells go into each heat source module. The figure below shows part of a heat source stack within the RTG.



### Risk Assessment and Launch Approval

Any mission that plans to use an RTG as a power source undergoes a safety analysis carried out by the Department of Energy (DoE). The safety analysis report provides a comprehensive assessment of the potential consequences of a broad range of possible launch accidents. In addition to the DOE review, an ad hoc Interagency Nuclear Safety

Review Panel (INSRP), which is supported by experts from government, industry and academia, is established as part of a Presidential nuclear safety launch approval process to evaluate the safety analysis report prepared by DOE. Based upon the INSRP evaluation and recommendations by DOE and other Federal agencies, NASA may then submit a request for nuclear safety launch approval to the White House Office of Science and Technology Policy (OSTP). The OSTP Director (i.e., the President's science adviser) may make the nuclear safety launch decision or refer the matter to the President. In either case, the launch cannot proceed until nuclear safety launch approval has been granted.

### SUMMARY

RTGs enable spacecraft to operate on missions where solar power systems would not be feasible. The Department of Energy is responsible for all aspects of RTG production and delivery to NASA, including safety analysis of the mission. RTGs can be used on NASA spacecraft only after this detailed safety analysis has been completed, reviewed by safety experts, and launch approval obtained from OSTP. RTGs have a proven record of safety and remain unmatched for reliability and durability over any other power technology for outer solar system missions.

For New Horizons, an RTG is uniquely capable of powering this reconnaissance mission to distant Pluto and the Kuiper Belt, where the Sun is no more than a bright point of light in the sky.

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