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Overview of NASA Program on Development of Radioisotope Power Systems with High Specific Power

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Advanced radioisotope power systems with high specific power (We/kg) are being developed to meet the needs of future NASA science and exploration missions. Technology portfolio includes the development of an advanced thermoelectric converter with a goal of 6 – 8 We/kg specific power and an advanced stirling radioisotope generator with a specific power goal of greater than 7 We/kg. Upon successful technology demonstration, one or both of these technologies have the potential to be transitioned to flight system development for post-2015 missions. In addition, advanced concepts are being developed to establish the feasibility of radioisotope power systems with specific power greater than 10 We/kg for post-2020 missions.

I. Introduction

Radioisotope Power Systems (RPSs) have been used for many past NASA space flight missions.[1] A key advantage of RPSs is their ability to operate continuously, independent of orientation to and distance from the Sun, making these systems ideal for outer planet missions. In additions, radioisotope power sources would be required for continuous operation in dark regions of Mars and Moon. Radioisotope systems are long-lived, compact and relatively insensitive to radiation and other environmental effects, which make them ideal for continuous operation in extreme environments of space and other planetary bodies.

The State-of-the-Practice RPS that has flown on most of the NASA missions is the General Purpose Heat Source Radioisotope Thermoelectric Generator (GPHS RTG)[1], which nominally generated 285 watts of electrical power at the beginning of its mission, and uses Pu^{238} fuel with a half life of 87.7 years. The GPHS RTG uses SiGe as its thermoelectric element and is designed for use in vacuum of deep space. The SiGe thermocouples used in GPHS RTG are no longer in production, although there are spare thermocouples from previous missions that can be refurbished to make another two generators.

NASA is currently developing a Multi-Mission Radioisotope Thermoelectric Generator (MMRTG)[2] that will be capable of operating both in the vacuum of deep space and in planetary atmospheres. The MMRTG is designed for more than 14-year life and has 125 We power at the beginning of mission, with 100 We of predicted power at the end of 14 years. It uses PbTe/TAGS thermocouples that have a history of use in the oxidizing atmosphere of Mars as well as in the vacuum of deep space. The first use for MMRTG will be the Mars Science Laboratory (MSL), planned to be launched in 2009.

While MSL is the only planned RPS-powered mission at this time, several future solar system exploration missions have been identified that will need RPS. These include Europa Explorer, Titan Explorer, Long duration Venus Explorer, Neptune Orbiter with Probe, Jovial Trojan Asteroid Orbiter, Mars Astrobiology Field Laboratory, and lander/rover in permanently shadowed region of Moon. These missions will answer several scientific questions regarding formation and evolution of planets, characteristics of the solar system that led to the origin of life, and presence of life elsewhere in the solar system. The other RPS-powered science missions are Solar Probe to fly into Sun's atmosphere or Corona and provide detailed characterization of solar wind, and interstellar probe to understand the nature of the interstellar medium. RPS is also being considered to provide surface power for lunar operations.

A key technology metric for RPS is power per unit mass, or specific power expressed as We/kg. The GPHS RTG system has a specific power of ~5 We/kg. The MMRTG system, because of its multimission

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