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Introduction: Many NASA missions given a high priority by the scientific community visit some of the harshest, darkest, coldest locations in the solar system, and these missions could not be possible or would be extremely limited, without the use of nuclear power. Radioisotope Power Systems—or RPS—that harness the heat of the natural decay of plutonium-238, to produce continuous electric power for operating spacecraft systems and science instruments. Radioisotope power has provided this "Power to Explore" for the past 60 years.

The first two space flights that used RPS were the Navy's Transit 4A and 4B navigational satellites, launched in June and November 1961. A 3-watt Radioisotope Thermoelectric Generator (RTG) was flown on each spacecraft to prove the operational capability of the RTGs in a space environment [1]. Since then, RTGs have flown on such missions as the Viking 2 landers, Pioneer 10 and 11, Voyager 1 and 2, Galileo, Ulysses, Cassini, and New Horizons.

The Mars Curiosity rover uses a newer RTG design called the Multi-Mission RTG, or MMRTG, that is based on RTG designs used for the Viking and Pioneer missions. The Perseverance rover that is expected to land on Mars in February 2021, and the Dragonfly rotorcraft that is scheduled to start exploring the surface of Titan in the mid 2030's is also baselined to be powered by a MMRTG.

The Next Generation RTG Project: The NASA RPS Program is actively working to assure the availability of high power, vacuum-rated RTGs to enable future deep space missions. The Next Generation RTG (NGRTG) Project is developing such a capability by building onto the GPHS-RTG design that powered the Ulysses, Galileo, Cassini and New Horizons missions [2]. The advantages of this approach include: a low risk building block development providing early mission capabilities (Mod 0), leveraging an existing RTG design, and allowing for a sustained, realistic "product improvement path" (Mod 1, Mod 2) for decades to come.

The multi-phased effort starts with the NGRTG Mod 0, which would deliver a refurbished, legacy GPHS-RTG qualification unit for use in the 2024 timeframe. The NGRTG Mod 1 would re-establish the production capability for the legacy RTG design and thermoelectric couples with required upgrades including the use of Step-2 General Purpose Heat Sources (Step-2 GPHS) and silicon-germanium unicouple converter technology updates for manufacturability. NGRTG Mod 1 is planned for availability in the 2028 timeframe. Missions planned in the early 2030's could benefit from a higher power and more modular NGRTG Mod 2 capability based on a Mod 1 "retrofit-ready" higher performance thermoelectric converter technology that is currently under development.

Performance: The primary goal for the NGRTG Mod 0, Mod 1, and Mod 2 configurations is to maintain the exemplary record for system reliability and minimal, graceful performance degradation that stretches back to the Voyager missions of the 1970's [2]. The Mod 0 and Mod 1 configurations are targeting power output performance on-par with the legacy GPHS-RTG design, with up to 295 W_e at beginning-of-life (BOL) and up to 210 W_e at end-of-design-life (EODL), 17 years after BOL including up to 3 years of ground storage. The Mod 2 configuration is targeting 290 W_e at EODL, which, assuming a similar total performance degradation that is comparable to Mod 0 and Mod 1, would translate to at least 400 W_e at BOL.

Uses: The NGRTG is being developed to provide power to deep space science missions, and its design would allow operation on earth during the pre-launch phase, in the vacuum of deep space in-transit, and in extreme temperature variations on the lunar surface. With an EODL power requirement of 17 years, the NGRTG could accommodate a long cruise time to the outer planets, or long duration missions to icy worlds, including powering flyby missions, landers, and rovers operating in vacuum environments.

The development of NGRTG for space science missions can also benefit lunar exploration. The first application for NGRTG may be for a lunar surface resource exploration rover at the south polar region, where photovoltaic power is not practical. Other uses could include electrical and thermal energy for an in-situ resource utilization (ISRU) pilot plant. In addition, prior to large fission reactor deployment, NGRTG could be used for auxiliary human habitation support. NGRTG Mod 0 could support a mission in the mid 2020's.

Exploration of Uranus/Neptune: Exploration of at least one ice giant system (Uranus or Neptune) has been identified as critical to advance our understanding of the solar system, its exoplanetary systems, and to advance our understanding of planetary formation and evolution. The NextGen RTG project is well positioned to support missions that have been proposed to explore one or both of these fascinating planetary systems [3].

References:

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