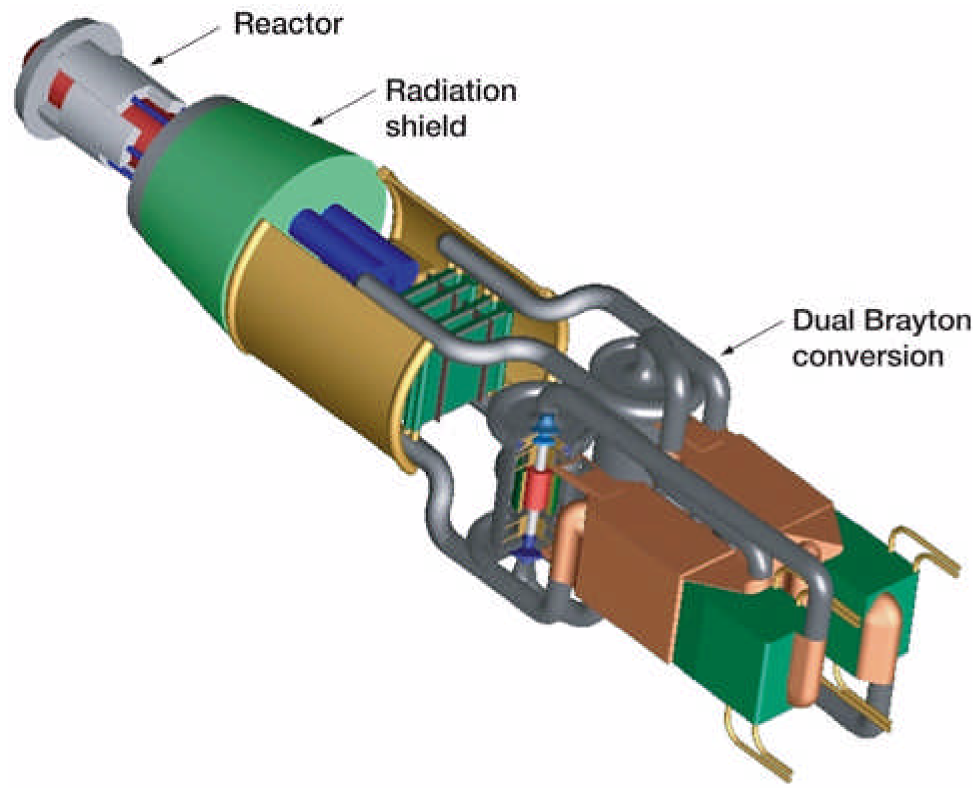
Power-Conversion Concept Designed for the Jupiter Icy Moons Orbiter

The Jupiter Icy Moons Orbiter (JIMO) is a bold new mission being developed by NASA's Office of Space Science under Project Prometheus. JIMO is examining the potential of nuclear electric propulsion (NEP) technology to efficiently deliver scientific payloads to three of Jupiter's moons: Callisto, Ganymede, and Europa. A critical element of the NEP spacecraft is the space reactor power system (SRPS), consisting of the nuclear reactor, power conversion, heat rejection, and power management and distribution (PMAD).



Dual 100-kWe Brayton conversion system with liquid-metal-cooled reactor.

The NASA Glenn Research Center participated in a joint NASA/Department of Energy study examining SRPS design options for missions such as JIMO. Glenn developed a potential SRPS architecture based on closed-Brayton-cycle power-conversion technology. For the study, researchers assumed a power level of 100 kWe for the NEP spacecraft and a liquid-metal-cooled reactor concept, although both heat-pipe and gas-cooled reactors are possible alternatives. The reactor subsystem includes a conical radiation shield to protect the spacecraft from reactor-induced gamma and neutron radiation. The power-conversion subsystem consists of two independent 100-kWe closed-Brayton-cycle converters (see the illustration) that provide 100-percent power-generation redundancy. The converter design is based on state-of-the-art superalloy hot-end construction that permits turbine inlet temperatures of 1150 K and cycle efficiencies in excess of 20 percent.

The only moving part is a single-shaft, radial turbocompressor that is supported by gas foil bearings.

High-voltage, three-phase alternating current is delivered by the rotary alternator to the PMAD subsystem, which includes two completely redundant modules, each capable of delivering 100 kWe to the spacecraft. Each PMAD module includes a 400-Vac bus for the high-power electric thruster loads and a 120-Vdc bus for the low-power spacecraft and science loads. Within the PMAD, a parasitic load radiator regulates the Brayton alternator speed by maintaining a constant load on the alternator regardless of spacecraft power demands. The waste-heat-rejection subsystem includes a pumped liquid-metal heat-transport loop and water heat-pipe radiator panels. The heat-transport loop interfaces with the Brayton gas coolers, allowing either or both Brayton units to utilize the full radiator surface. The radiator consists of two planar wings, each having a series of staircased, deployable rectangular panels that are contained within the radiation shield half-angle and that provide two-sided heat rejection.

Many tradeoff studies were performed in arriving at this candidate power system concept. System-level studies examined design and off-design operating modes, determined startup requirements, evaluated subsystem redundancy options, and quantified the mass and radiator area of space reactor power systems from 20 to 200 kWe. For the Brayton converter subsystem, studies investigated converter packaging options and assessed the torque effects induced on spacecraft dynamics by rotating machinery. For the heat-rejection subsystem, design tradeoff studies were conducted on heat-transport approaches, material and fluid options, and deployed radiator geometries. For the PMAD subsystem, the overall electrical architecture was defined and tradeoff studies examined distribution approaches, voltage levels, and cabling options.

Find out more about this research: http://www.grc.nasa.gov/WWW/tmsb/

Glenn contact: Lee S. Mason, 216-977-7106, Lee.S.Mason@nasa.gov
Author: Lee S. Mason
Headquarters program office: OSS
Programs/Projects: Prometheus, JIMO