NASA SBIR 2005 Phase I Solicitation

X10.03  Critical Technologies for Space-Based Nuclear Fission Power Systems

Lead Center: GRC

Participating Center(s): JPL, JSC, MSFC

NASA is interested in the development of highly advanced systems, subsystems, and components for use with high-power, fission power systems for a variety of future robotic and manned exploration missions to the Moon, Mars, and beyond. Anticipated electric power levels range from 30 to 100s of kilowatts for the nearer-term and possibly up to multi-megawatts for the far-term. Fission-based systems are anticipated to enable long duration stays of approximately 45 to 90 days over the lunar night and may have in situ resource utilization applications. Power levels needs are anticipated to be between 30-50 kWe for these early exploration missions.

Potential Mars-surface human outpost applications for high-power space nuclear power systems could include habitats, resource processing, propellant production/liquefaction/maintenance, and excavating and mining equipment. These potential Mars surface human mission activities could require power in the 100 kWe range. Also, space nuclear power systems could be needed for robotic outposts as a precursor to human Mars surface exploration with 50-500 day stays. Power levels of about 30-50 kWe may be needed to support these initial robotic outposts and other science applications such as: deep drilling, resource production demonstrations, rovers, weather stations, etc.

Potential electric propulsion applications include high power space nuclear power systems for primary electric propulsion, vehicle housekeeping, cryogenic propellant maintenance, orbiting power assets and science payloads. Power levels in the 100-200 kWe range are envisioned for robotic vehicles. Far-term vehicles for human missions may also be needed and could require about 1-2 MWe for high-mass cargo vehicles to the Moon or Mars and the low 10s of MWe for piloted electric propulsion vehicles. Nuclear thermal propulsion systems could also be designed to produce electric power and power levels of about 50 kWe could be needed to meet crew habitat, propellant boil-off, and other spacecraft power requirements.

Proposals are sought in the following specific technologies areas:

- Advanced, high-efficiency, high-temperature high-power conversion >20%, 30-200 kWe for the nearer-term, and up to MWe-unit size for the far-term (with technical issues of scaling to high power unit);
• Electrical power management, control and distribution in the 1000-5000 V range;

• Deployment systems/mechanisms and innovative methodologies for surface mobility systems for remote emplacement of power systems and for use of indigenous shielding materials;

• Material compatibility with local environments;

• Systems/technologies to mitigate lunar and planetary surface environments including dust accumulation, lunar surface temperature extremes, wind, planetary atmospheres (CO₂, corrosive soils, etc.);

• Power system design considerations for long life (>10 years), autonomous control and operation, including sensor technologies; and

• Radiation tolerant systems and materials (including lunar, Mars and in-space environments) for robust, long-life operation.

In addition to reducing overall system mass, volume and cost, increased safety, and reliability are of extreme importance. It is envisioned that these high power space nuclear power system technologies could be used on robotic and human exploration missions and it is to NASA’s advantage to develop those technologies that evolve from robotic to human exploration mission requirements with a minimum of redesign. Technologies that enable challenging missions such as, nuclear electric propulsion, planetary surface power, and in-space electric power generation are of particular interest. Technologies that easily and efficiently scale in power output and can be used in a host of applications (high commonality) are desired.

Proposals for thermal management systems and innovative materials computational engineering should be proposed to X10.04 and X10.05, respectively.