Space Fission Reactor Power Systems

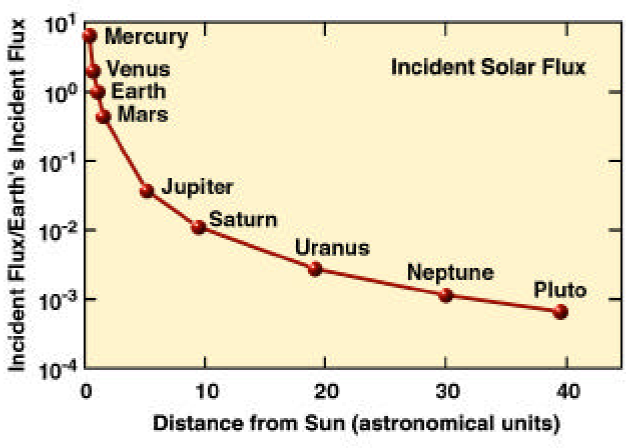
Their Use and Safety

February 2003

Space missions require a reliable source of electrical power. Space experiments and applications, electric propulsion systems, the monitoring and maintenance of spacecraft, and the transmission of information back to Earth cannot be accomplished without sufficient electrical power. Space fission reactor power systems convert heat generated by nuclear fission into electricity. This fact sheet discusses how nuclear fission reactors could be safely used in space.

Why Would Fission Reactor Power Be Needed in Space?

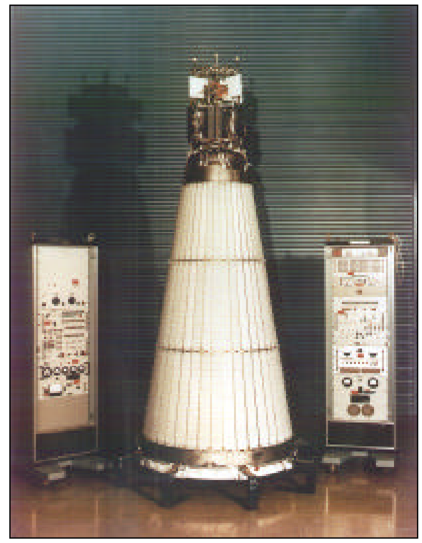
Nuclear fission power for spacecraft would allow a change in approach to Solar System exploration by making it possible, in two important ways, to: (1) propel spacecraft directly to the planets in ways not possible today, and perform orbital maneuvers once there; and (2) provide ample electrical power to operate advanced scientific instrument suites that have higher power requirements than instruments used at present. This new



technology would enable multi-destination missions capable of entering into orbit around one body, conducting observations, and then departing to a new destination on a voyage of exploration which could last many years. Scientific robotic missions such as these will require large amounts of power continuously, for long periods of time, in locations where the Sun's intensity is no more than 1/1000th its level near Earth. At this time, solar and chemical power sources cannot meet anticipated power demands for the advanced spacecraft NASA envisions. A space fission reactor power system could provide tens to hundreds of kilowatts of electric power continuously for years, anywhere in the Solar System, where no other means of high-power electric power generation is possible.

Unlike solar cells, space reactor power systems provide power independently of spacecraft orientation or proximity to the Sun. Nuclear radioisotope power sources (e.g. Radioisotope Thermoelectric Generators), although long-lived and not dependent on sunlight, are better suited to meeting smaller (<1 kilowatt) power requirements. Only fission reactor systems can meet the higher-level, long-term electrical power needs of many potential future space missions.

Have Reactor Power Systems Been Used in Space?



SNAP-10A Reactor System

Yes. Space nuclear reactor technology is not new. The U.S. successfully launched the SNAP-10A space reactor power system in 1965. This was the first fission reactor to be operated in space, however, the U.S. has to date successfully met its deep space, long-term power needs using radioisotope power systems. As we move from surveying the planets to exploring them, mission power requirements are expected to exceed the threshold that radioisotope power systems are capable of providing.

Can Space-Based Fission Reactor Power Systems Be Used Safely?

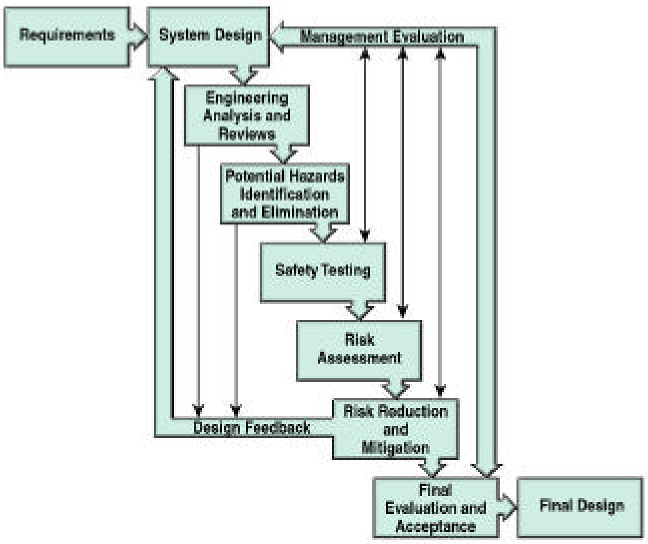
Yes. Safety is the most fundamental and important consideration in every aspect of space mission design including those using space fission reactor power systems. Safety must be assured during pre-launch, launch, mission operation, and post-operation phases.

A rigorous safety assessment based on testing and analysis is required to be performed to ensure the safety of the public and the environment during launch. Only when the system has securely reached its planned startup orbit or interplanetary trajectory will the reactor be turned on (i.e., made 'critical') to generate power for the spacecraft. After mission completion, in order to reduce potential risks to Earth or other planetary bodies, 'safekeeping' orbits will be designed that would ensure that the fission reactor system will stay in space indefinitely or long enough to allow radioactivity produced during operation to safely and naturally decay away.

How Would the Safety of These Systems Be Maximized?

Safety is maximized via an "Integrated Safety Management" approach and philosophy and a pre-launch work process that incorporates several elements: (1)Mission and System Design and Testing, (2) Safety and Quality Assurance, and (3)

Independent Safety Review and Nuclear Safety Launch Approval. A hierarchy of safety goals, objectives, criteria, requirements, and specifications are employed to preclude or minimize potential exposures to radioactive and toxic materials, and assure security and protection of fissionable materials.

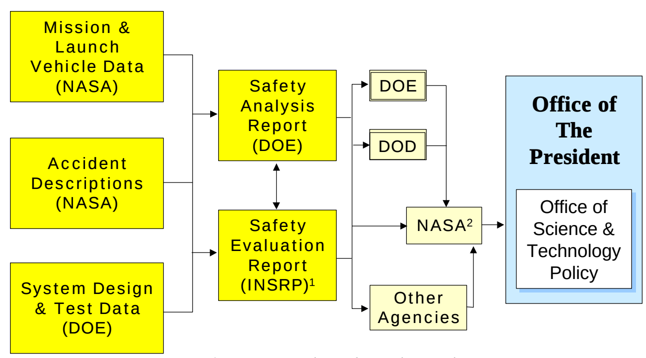


Mission and System Design. Safety will be designed into the mission and system from the inception of the design process. Safety requirements are established at the outset of the design process. System designers will work at every level to ensure the system will meet these design requirements. Typical requirements include the ability to operate reliably without continual actions from ground control, the ability to keep the reactor in a subcritical state prior to startup and under various accident scenarios, the ability to remove operational and decay heat during specified normal and off-normal operating conditions, and the ability to reliably perform all necessary control and safety functions. The systems will be analyzed and tested to ensure that, as built, they will meet all design requirements.

Safety and Quality Assurance. Engineering analyses and reviews are normally performed to identify and mitigate potential hazards. Safety testing and risk assessments will be used for safety design confirmation and quantification of any remaining risks. The results of these analyses and tests will provide important design feedback so that design modifications can be made to enhance safety and reduce risk. Test articles (e.g., materials and components) will be subjected to rigorous testing in conditions more severe than those to be encountered during the mission so that designers will have a clear understanding of system performance and safety margins. All flight hardware and software would be subjected to a battery of "acceptance tests", designed to ensure that fabrication and assembly specifications are met at all subsystem and system levels.

Independent Safety Review and Nuclear Safety Launch Approval. Nuclear safety launch approval for U.S. space missions involving the use of nuclear systems is based on careful consideration of the projected benefits and risks of the proposed mission. The analysis of potential consequences will be based upon a detailed understanding of the potential accident environment, characterization of the fission reactor system responses based upon testing and analyses, modeling of how any potential releases might be transported, and in turn, estimates of potential public exposure and the consequences of those exposures. In addition to internal agency reviews for missions that involve nuclear power systems, an *ad hoc* Interagency Nuclear Safety Review Panel (INSRP) is established as part of a Presidential nuclear safety launch approval process to evaluate the safety analysis report prepared by the DOE. Based upon recommendations by DOE and other agencies and the INSRP evaluation, where other than very small amounts of radioactive material are involved, NASA submits a request for nuclear safety launch approval to the White House Office of Science and Technology Policy (OSTP). The OSTP Director may make the decision or refer the matter to the President. In either case, the normal process for launch cannot proceed until nuclear safety launch approval has been granted.

Nuclear Safety Review and Launch Approval Process



1 Interagency Nuclear Safety Review Panel
2 Responsible mission agency makes launch recommendation

Space Fission Reactor Power — Safe, Advanced Technology For the Future

NASA and the U.S. Department of Energy are committed to providing safe, reliable space fission power technology to enable and enhance our nation's space exploration program. Space reactor power systems are capable of facilitating exciting new exploration missions that will advance humanity's understanding of the universe and our place in it.

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