DISCOVERY AO
LIGHTWEIGHT RADIOISOTOPE HEATER UNIT (LWRHU) INFORMATION SUMMARY
September 2009

All Lightweight Radioisotope Heater Units (LWRHUs, commonly referred to simply as RHUs), used in missions proposed for this AO, including the services associated with their provisioning on space missions (e.g., National Environmental Policy Act (NEPA) Compliance, Nuclear Safety Launch Approval, Emergency Preparedness and Planning), will be purchased by NASA from the Department of Energy (DOE) and provided as Government Furnished Equipment (GFE) and Services (GFS). Funding for these units and services will be provided directly by the Discovery Program, and budgeted within the cost cap for each selected mission.

This document describes the RHUs that would be made available to proposed missions, provides additional links and contact information as resources for developing proposals, and contains general information concerning special considerations that have to be taken when proposing to use RHUs. During Phase A study of the selected mission concepts, the teams that have proposed use of RHUs in their missions will be provided a NASA Point of Contact (POC) who will support them in developing more refined approaches and cost estimates for accommodation of RHUs.

1.0 Introduction

Most spacecraft can use solar energy to provide heat to keep their structure, systems, and instruments warm enough to operate effectively. However, when solar or other heat source technologies are not feasible, an alternate heat source is required for the spacecraft. By using RHUs, the spacecraft designer can allocate scarce spacecraft electrical power to operate the spacecraft systems and instruments. RHUs also provide the added benefit of reducing the potential for electromagnetic interference generated by electrical heating systems.
Characteristics of RHUs include:
Highly reliable, continuous, and predictable output of heat.
No moving parts.
Compact structure.
Resistance to radiation and meteorite damage.
Heat produced is independent of distance from the sun.

RHUs provide proven and reliable continuous heat to sensitive spacecraft instruments and scientific experiments enabling their successful operation throughout the mission. RHUs generate heat from the natural radioactive decay of a small pellet of plutonium dioxide (mostly plutonium-238). This heat is transferred to spacecraft structures, systems, and instruments directly without moving parts or intervening electronic components. RHUs are very compact, 3.2 centimeters (1.3 inches) long and 2.6 centimeters (1 inch) in diameter. The mass of each RHU is approximately 40 grams (1.4 ounces). Because of their varying ages, the RHUs available from DOE's inventory range in thermal power from 0.88 to 0.94 watts. Their average is approximately 0.93 watts per RHU as of September 2009.

RHUs have a very rugged containment system to prevent or minimize the release of plutonium dioxide fuel even when subjected to severe accident conditions. Containment is achieved through multiple layers that are resistant to the heat and impact that might be encountered during a spacecraft accident. An external graphite aeroshell (a reentry shield) and a graphite insulator protect the fuel from impacts, fires, and atmospheric reentry conditions. Internally, the fuel is encapsulated in a high-strength, platinum-rhodium metal shell (or "clad") that further contains and protects the fuel during any potential accident.

In addition to this containment, the plutonium dioxide fuel is a ceramic material that tends to break into large pieces rather than dispersing as fine particles. This minimizes interaction of the fuel with the environment and the potential for human exposure in the unlikely event that the multiple fuel containment barriers are breached. Because each RHU fuel pellet is individually encapsulated in its own aeroshell and fuel clad, the potential for a single event to affect more than one pellet is reduced. The following sections provide more information relevant to the provisioning of RHUs for the Discovery AO. Section 2.0 provides links and contact information for additional information about RHUs. Section 3.0 summarizes all of the activities, processes and costs that AO respondents should assume in proposing a mission potentially utilizing RHUs.

2.0 Additional Information

General questions concerning RHU technical details (e.g., technical specifications, spacecraft integration) should be directed to the Department of Energy's Office of Radioisotope Power Systems, Alice Caponiti at 301-903-6062.

3.0 Provisioning of RHUs for Discovery Missions

Potential use of RHUs in space requires many special considerations that must be accounted for in the budgeting and scheduling of a space mission. Most of these elements, such as National Environmental Policy Act (NEPA) Compliance and Nuclear Safety Launch Approval (NSLA), are well-defined, multi-year processes involving development of specific documentation and coordination among several government agencies.

Many of these elements are delineated in NASA guidelines available through links in the Discovery Program Library, while some have evolved as accepted practices over the years. For the Discovery AO, the special considerations for use of RHUs have been divided into the six elements described below.

3.1 NEPA Compliance

NEPA requires federal agencies to consider, before an action is taken, environmental values in the planning of activities that may have a significant impact on the quality of the human environment. NEPA accomplishes this by directing agencies to evaluate alternative courses of action that may mitigate the potential environmental impact of a planned activity, such as use of radioactive material on a space mission. NASA's implementing regulations for NEPA can be found at 14 CFR 1216.1 and 1216.3. These regulations specify actions that can be expected to have a significant effect on the quality of the human environment. Such actions, which include the development and operation of nuclear systems, require preparation of an EIS.

Development of the EIS commences as early as possible in the development program, with a target for completion by Critical Design Review (CDR) or earlier. NASA Headquarters is responsible for preparation of the EIS and has enlisted subcontractors to assist in its development. When missions plan to use RHUs, development of the EIS also requires development of a nuclear risk assessment by the Department of Energy (DOE) and participation by NASA Kennedy Space Center (KSC) and the Jet Propulsion Laboratory (JPL), NASA's launch nuclear approval engineering technical representative.

3.2 Nuclear Safety Launch Approval (NSLA)

For any U.S. space mission involving use of nuclear energy for heating or electrical power, launch approval must be obtained from the Office of the President per Presidential Directive/National Security Council Memorandum #25 (PD/NSC-25) paragraph 9. The approval decision is based on an established and proven review process that includes an independent evaluation by an ad hoc Interagency Nuclear Safety Review Panel (INSRP). The NSLA begins with development of a launch vehicle databook (i.e., a compendium of information describing the mission, launch system, and potential accident scenarios) by NASA. DOE uses the databook to prepare safety analysis documentation for the space mission, which is submitted to the INSRP.

After an extensive inter-agency review process, if the NASA Administrator recommends proceeding with the launch, then a request for nuclear safety launch approval is sent to the Office of Science and Technology Policy (OSTP) within the Office of the President.

NASA Headquarters is responsible for implementing the NSLA process for NASA missions. It generally enlists JPL to assist in this activity. DOE supports the process by analyzing the response of RPS hardware to the different accident scenarios identified in the databook and preparing a probabilistic risk assessment of the potential radiological consequences and risks to the public and the environment for the mission. NASA KSC is responsible for overseeing development of databooks and typically uses JPL to characterize accident environments. KSC subcontractors provide information relevant to launch vehicle accident probability analysis, and other contractors assist in performing impact assessments and analyses. The development team ultimately selected for this Discovery mission would be responsible for providing payload descriptions, describing how the nuclear hardware integrates into the spacecraft, describing the mission and supporting NASA KSC and JPL in their development of the databooks for the EIS and NSLA processes. DOE requires completion of a mission's launch vehicle databook at least three years prior to launch.

3.3 Emergency Preparedness and Planning

Any launch involving significant amounts of radioisotope materials (e.g., RHUs, radioisotope power systems) requires special accommodations at the launch site to ensure mitigation of associated hazards arising from an unlikely launch anomaly. This activity involves deployment of emergency response teams at the launch site and preparations to respond to any launch contingencies with radioisotope materials onboard. It also includes the detailed planning that must be conducted prior to deployment of these assets, including formulation of procedures for handling different accident scenarios. The radiological emergency preparedness and planning requirements are tailored for each launch based on the understood risk (documented in the FSAR) and experience/lessons learned from previous missions using radioisotope materials.

NASA has responsibility for overall emergency preparedness and planning. As part of that effort, DOE supports the planning and preparedness functions, both on- and off-site, associated with any response to launch anomalies possibly involving the release of radiological materials. DOE would provide the initial radiological response team, including command and control, for resources off-site. The funding for these activities would be provided to DOE directly by NASA as part of the overall project cost.

3.4 RHU/Spacecraft Accommodations, Processing and Integration

Use of RHUs requires special provisions for accommodations and processing at the launch site. There are also unique aspects, such as high temperatures and personnel radiological safety, that must be considered when integrating the unit(s) with the spacecraft at the launch site. RHUs also require special security to protect the units and the radioisotope fuel. Planning for the use of RHUs begins early in the design process and culminates in activities directly supporting processing and integration at the launch site.

3.5 Risk Communication

Due to the unique risks associated with the use of nuclear materials, a risk communication plan will be established early in the mission planning process to ensure that information concerning mission risks is accurate and understandable. The risk communication plan will serve as a guide for interacting with external audiences regarding the safety and acceptability of the mission and will identify project-specific roles and responsibilities of offices and individuals and the activities, products and schedules specific to communicating nuclear launch safety, planetary protection or other matters that may spark public concern.

3.6 Costs

Proposers should use an average cost of $3000/RHU. That is a hardware-only cost, for RHUs currently in inventory (which are the only items being offered). This cost does not include other costs detailed in the AO, Section 5.2.4.4, such as nuclear launch approval, NEPA and nuclear launch services.