Low Power Long Life Radioisotope Power Systems

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Concept Motivation

- Investigate potential application of radioisotope heater unit (RHU) based radioisotope power system (RPS)
  - Provides constant and continuous power and heat for electronic systems and battery
  - Based concepts developed in the early 1980’s,
    - 1.0 Wth, 40 mWe design capable of over 2000 g landing loads
- Focus on small spacecraft with low power/energy demands
- Try to capitalize on heritage cubesat technologies developed for LEO but targeted for lunar applications
- Potential applications for “ground truth” polar ice verification or small multi-station seismometry
- Develop a modular power/energy unit that can integrate with other cube systems/instruments increasing capability into a multi-cube platforms
- Goal to keep mission costs to Discovery level or less
Why Lunar Focus?

• Close to Earth
  – Short trip times maximize life of RPS for the science gathering portion of a mission
    • 5 day vs. a 10+ year trip time for outer planets
  – RPS enables longer term missions in permanently shadowed regions and operation through the long lunar nights
  – Long term power generation lifetimes 10’s of years
  – Also reduces comm system (antenna size and power) as compared to long distance destinations
  – Landed mission science offers potential reduced need for high data rates (not flyby for example)
RHU-RPS Components

Radioisotope Heater Unit
Heat output: 1 watt
Weight: 1.4 ounces
Size: 1 inch x 1.3 inches

Thermoelectric Module
Hi-Z Technology Inc. - 40 mWe RHU-RPS

RHURPS unit is too tall for a single cube, but the RHURPS, batteries and controller card will fit within two cubes.

Note: Engineering Unit tested for 9 years with Pu238 heat source at Los Alamos National Lab
Major Components of the Power Cube Concept

- COTS Controller/battery charger card
- RHURPS
- Rechargeable Li ion Battery

Fig. 1: VES16 Li-ion space cell
RHURPS, batteries and controller fit in a 2 U Arrangement

• RHURPS- Hi-Z, 40 mWe, 2.5 V (6.2 cm Dia. X 13.4 cm)

• Li-ion batteries-
  - Battery can be easily sized for mission needs (free volume allows ~ 200 W-hr max)
  3.3 cm dia, 18 cm tall (up to 12 - 16 W-hr cells) exp. Saft VES 16

• Voltage controller/battery charger
Radioisotope Power Systems Program

RHU-RPS System

Side View

Top View

Mass Estimate:
RHURPS - 750 gm
Controller Card - 80 gm
Li-ion battery (200 Whr) 1860 gm
Cable harness 30 gm
2U Structure - 2720 gm

2000 gm
Example CubeSat Heritage Systems

Source: JPL
X-Band Radio

Source: Tethers Unlimited
Micro Thruster
RHURPS Example Missions

Lunar Volatiles

**Hard Lander Missions**

- Lcross-type hard impactors
- Die on impact; kick up ejecta
- Following and/or an orbital asset to watch ejecta plume
- Use to test make up of promising areas

**Survivable hard landers**

- Encase instruments in crushable material (e.g., Al foam)
- Pallet of 12-20 probes
- De-orbit with solid at 10 km perilune, free-fall to surface (90 seconds; impact velocity ~100-200 m/s)
- Spherical shape with offset CG (assumes correct orientation)
- Collect data, radio results to orbiter, die (mission duration ~few hrs)
- Map point analyses; ground truth orbital data

Source: LEAG meeting, 2015

Lunar Seismometry

**Spudis**

Manifested on the InSight Mission

Source: Imperial College, London, UK
Higher Power RPS for Lunar Missions

NF Lunar Geophysical Network
Observations

- RHU-RPS fits within 2U and includes: 40 mWe radioisotope unit, batteries and controller cards.
- Building block for a lunar lander/probes integrated with cubes devoted to science instruments
- Allows network type missions - many smaller and lower cost landed systems
  - Seismometry
  - Location and distribution of water ice/volatiles within PSR’s
  - Possible detection of on-going/future volatiles accretion rates
  - Long term detection and observation of lunar swirls
- Multiple lander/probe systems can be delivered on one or more carrier stages per launch vehicle.
  - Potentially could target several locations of interest with multiple small lander/probe systems
RPS Program Overview

- MMRTG is the current flight system available
  - Next use is on the Mars 2020 Rover
- Three Units have been offered to proposers for the New Frontiers 4 AO Solicitation
- Currently in development is new thermoelectric technology to enhance the MMRTG (eMMRTG)
  - ~20% increase in initial power and 50% increase in end of mission power
  - Decision in 2018 on readiness of this technology in adopting to flight hardware
- Planned study to identify the appropriate RPS characteristics and performance for future planetary missions
- Planned program to evaluate and develop a higher performance RPS system using highly efficient dynamic conversion technology
Lunar Mission Needs for RPS

• The Radioisotope Program Office is interested in capturing the RPS characteristics seen by the lunar community to enable challenging science, exploration and prospecting on the moon.

• Please email rps@nasa.gov with mission concepts and RPS technology needs

• Please visit rps.nasa.gov for future information and updates