RADIOISOTOPE POWER SYSTEM WASTE HEAT MITIGATION FOR ICE AND OCEAN WORLD SURFACE EXPLORATION. B. K. Bairstow[1], Y. H. Lee[1], S. Howell[1], B. Donitz[1], M. Choukroun[1], S. Perl[1], T. Balint[1], A. Austin[1], [1]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., Pasadena, CA, 91109 (brian.k.bairstow@jpl.nasa.gov, young.h.lee@jpl.nasa.gov, samuel.m.howell@jpl.nasa.gov, benjamin.p.donitz@jpl.nasa.gov, mathieu.choukroun@jpl.nasa.gov, scott.m.perl@jpl.nasa.gov, tibor.balint@jpl.nasa.gov, alexander.austin@jpl.nasa.gov)

Introduction: The extremely low temperature and pressure at the surface of most Ocean and Ice Worlds pose a challenge to surface exploration missions using Radioisotope Power Systems (RPS), due to the heat rejection mitigation to prevent the surface ice from melting or sublimating. Minimizing sublimation and melting of the top layers of ice at destinations like Europa or Enceladus could be necessary for preserving science investigations and remaining compliant with planetary protection regulations.

The RPS program conducted a mission formulation study within JPL's Team X concurrent design environment to investigate the system-level impact of a heat rejection system that could be required for RPS-enabled exploration of Ocean and Ice Worlds. The scope of the study included finding the baseline mass and volume of a thermal shield needed to reject enough RPS excess heat to remain within a pre-determined surface flux, governed by the surface characteristics of the target body.

The study team first characterized the (1) thermal conductivity parameters, including ice purity; (2) surface porosity; and (3) surface temperature, of 21 targets of Ocean and Ice Worlds, then defined a maximum allowable surface heat flux, parametrized by the three aforementioned characteristics. The target bodies were subsequently mapped to a maximum allowable heat flux, determined by notional planetary protection and science requirements. Note that worlds with atmospheres, like Titan, were considered out of scope for this study. Planetary protection was the driving requirement for the heat flux - it mandates that the surface sublimation shall not exceed 10 cm over two years and that no melting shall occur.

The study team then focused on two bodies of interest, Europa and Enceladus, which act as bounding cases in the space of Ocean and Ice Worlds. The study team found that Enceladus, which has an extremely cold surface and thus is harder to warm, could tolerate up to 100 W/m^2 heat flux at the surface to remain compliant, while Europa, which has a relatively warmer surface, could only tolerate up to 10 W/m^2.

Thermal engineers modeled the effects of placing a variety of RPS on the surface of both these moons, and varied the excess heat rejected by the power system; the height of the system off the surface; and the orientation of the RPS with respect to the surface (i.e., vertical with the ends facing the surface, or horizontal with the fins facing the surface). The engineers proceeded to design a thermal shield – situated between the RPS and the surface – for each case that would prevent the heat flux from exceeding the requirement and the RPS from overheating. In total, 18 cases were investigated. Mechanical engineers, along with the thermal engineers, determined the mass and size of the notional thermal shields, required to create planetary protection compliant, RPS-enabled Ocean and Ice Worlds landers.

This poster describes the approach, results, and planned future work of the study.

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