Mechanics/Machinery

Optimized Radiator Geometries for Hot Lunar Thermal Environments

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The optimum radiator configuration in hot lunar thermal environments is one in which the radiator is parallel to the ground and has no view to the hot lunar surface. However, typical spacecraft configurations have limited real estate available for top-mounted radiators, resulting in a desire to use the spacecraft's vertically oriented sides. Vertically oriented, flat panel radiators will have a large view factor to the lunar surface, and thus will be subjected to significant incident lunar infrared heat. Consequently, radiator fluid temperatures will need to exceed ≈325 K (assuming standard spacecraft radiator optical properties) in order to provide positive heat rejection at lunar noon. Such temperatures are too high for crewed spacecraft applications in which a heat pump is to be avoided.

A recent study of vertically oriented radiator configurations subjected to lunar noon thermal environments led to the discovery of a novel radiator concept that yielded positive heat rejection at lower fluid temperatures. This radiator configuration, called the Intense Thermal Infrared Reflector (ITIR), has exhibited superior performance to all previously analyzed concepts in terms of heat rejection in the lunar noon thermal environment. A key benefit of ITIR is the absence of louvers or other moving parts and its simple geometry (no parabolic shapes). ITIR consists of a specularly reflective shielding surface and a diffuse radiating surface joined to form a horizontally oriented V-shape (shielding surface on top). The point of intersection of these surfaces is defined by two angles, those which define the tilt of each surface with respect to the local horizontal. The optimum set of these angles is determined on a case-by-case basis. The idea assumes minimal conductive heat transfer between shielding and radiating surfaces, and a practical design would likely stack sets of these surfaces on top of one another to reduce radiator thickness.

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A Mission Concept: Re-Entry Hopper-Aero-Space-Craft System on-Mars (REARM-Mars)

A reusable lander, hopper, sample-return collector cargo system (all-in-one) is proposed for Mars.

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Future missions to Mars that would need a sophisticated lander, hopper, or rover could benefit from the REARM Architecture. The mission concept REARM Architecture is designed to provide unprecedented capabilities for future Mars exploration missions, including human exploration and possible sample-return missions, as a reusable lander, ascend/descend vehicle, refuelable hopper, multiple-location sample-return collector, laboratory, and a cargo system for assets and humans. These could all be possible by adding just a single customized Re-Entry-Hopper-Aero-Space-Craft System, called REARM-spacecraft, and a docking station at the Martian orbit, called REARM-dock. REARM could dramatically decrease the time and the expense required to launch new exploratory missions on Mars by making them less dependent on Earth and by reusing the assets already designed, built, and sent to Mars. REARM would introduce a new class of Mars exploration missions, which could explore much larger expanses of Mars in a much faster fashion and with much more sophisticated lab instruments.

The proposed REARM architecture consists of the following subsystems:

- **REARM-dock** that would orbit Mars could host both the spaceship traveling between Earth and the Martian orbit, as well as the REARM-spacecraft. It would repeatedly receive cargo shipped from Earth. It could also receive sample-return containers and would load them into the Earth spaceship for return to Earth. A compartment has been envisioned in the middle of the REARM-dock that would perform the exchange of cargo between the Earth spaceships and the Martian REARM-spacecraft. The cargo coming from Earth could include caches of propellant, MPEs (modular propulsion elements), batteries, spare parts for the rovers or REARM system, as well as new science payloads, which could be installed on existing rovers and sample-return containers.
- The **REARM-spacecraft** is envisioned to be a re-entry vehicle that could make round trips between the Martian orbiter and the surface of Mars using MPEs coming from the Earth, or could be solar and battery-powered similar to X37B. It would function in three different modes: (i) As a re-entry ascent/descent vehicle, cycling from the orbiter down to the surface of Mars; (ii) As a hopper, travelling (hopping) along the surface of Mars in order to relocate the rovers and other assets on