

Enabling Mercury Dayside Operations and Science

Background and Objective

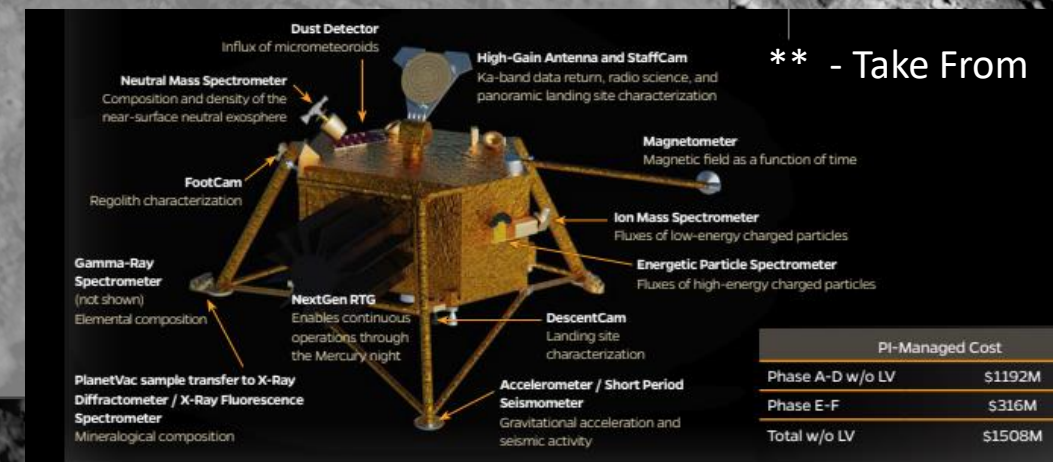
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- A Mercury lander was studied as part of the recent NASA planetary decadal survey process – mission concept would operate for one night after landing around dusk.
- Challenges were the mass (insertion and landing), **dayside temperature on the surface**, and communication back to Earth.
- A team of engineers and scientists led by NASA GRC*, and including CWRU*, APL* and JPL* explored ways to enhance the science, and extend the duration of the Mercury lander concept mission.
- Results are promising!

* GRC = Glenn Research Center,
CWRU = Case Western Reserve University,
APL = Johns Hopkins Applied Physics Laboratory,
JPL = Jet Propulsion Laboratory

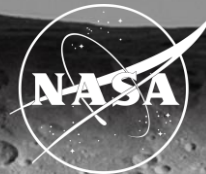
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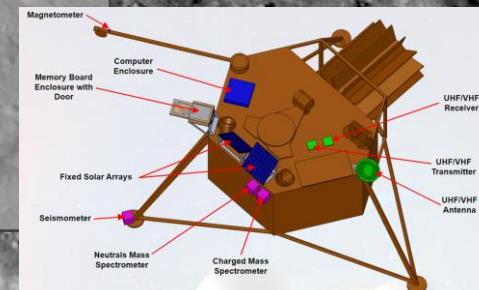
** Mercury Lander Concept Study Report. C. Ernst, et al, [Planetary Science Decadal Survey](#)

Enhancing Science with New Capability

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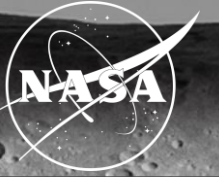
- NASA has been investing in high-temp systems for years. This includes developing lander capabilities for Venus (surface temps ~460 C).
 - All lander subsystems (E.g. avionics, instruments, power, and communication) have made notable progress. Many components demonstrated successful operations for thousands of hours at > 450C.
- A recent study showed the viability of operating a targeted science package (geophysics and space weather) over a Mercury day.
 - Would extend some lander science by a Mercury year, or longer.
 - Add high temperature instruments (seismometer, magnetometer, fields measurement), high-temp power system, and communication system and a cooled box for data storage
 - Reported at the 2024 Mercury conference (Poster: “*Capabilities for Long-Duration Landers On Mercury*”, Kremic, T. et. al., 2024)
- Impacts to lander are accommodating ~20kg of high-temp hardware on lander (~\$25M adder to lander)
 - Orbiter needed for data relay so additional mass/cost to keep orbiter operating another Mercury year. Significant mass and ~\$70M added to orbiter



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Science Enhancing Concepts

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A study of the RTG/power system was also conducted exploring the feasibility of operating the RTG night and day.

- ***Mission impact – Communicate DTE during night, Store data during day and cool critical components, day & night power to payloads and critical systems. Standard electronics cooled in vault during day by RTG power.***
- ***Can extend mission to multiple years.***

Several approaches available with differing degrees of difficulty and impact.

Concept A / Requirements and Cases

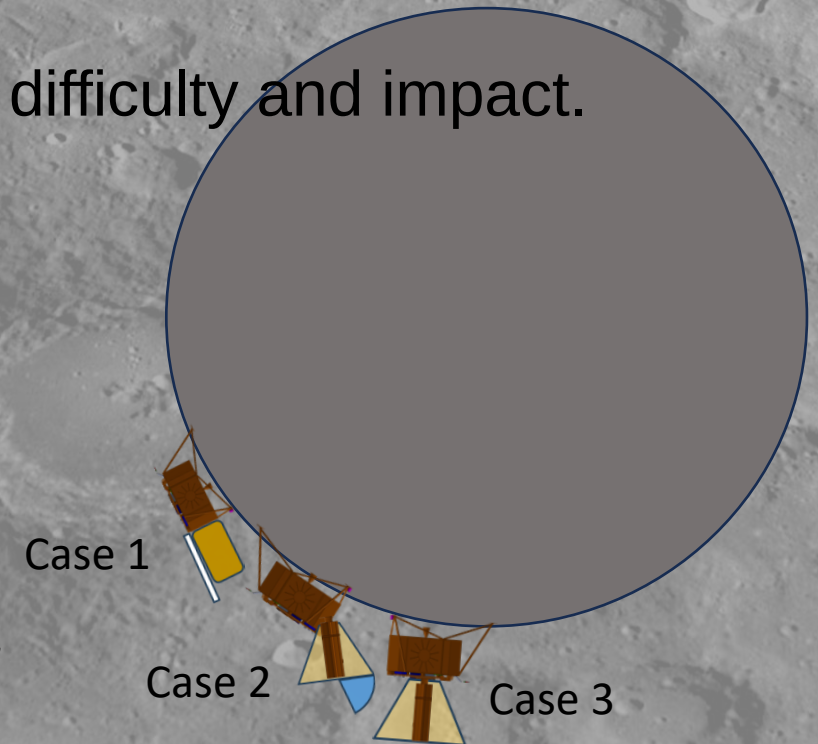
Note: Little or no changes to RTG

- 1) Above $\sim 40^\circ$ to $\sim 60^\circ$, RTG in insulated box with coated zenith facing radiator. Heat pipe interface to RTG required.
- 2) $\sim 60^\circ$ to $\sim 85^\circ$, shielding required to block sun **& surface IR**. RTG pointed to pole.
- 3) Near the poles only passive sunshield needed to block sun.

Concept B / Requirements

Note: Some RTG mods needed

- A. RTG can operate anywhere as can high-temp instruments and systems.
- B. Additional power (E.g. second RTG or high-temp solar) required for cooling of standard electronics, if below $\sim 40^\circ$.

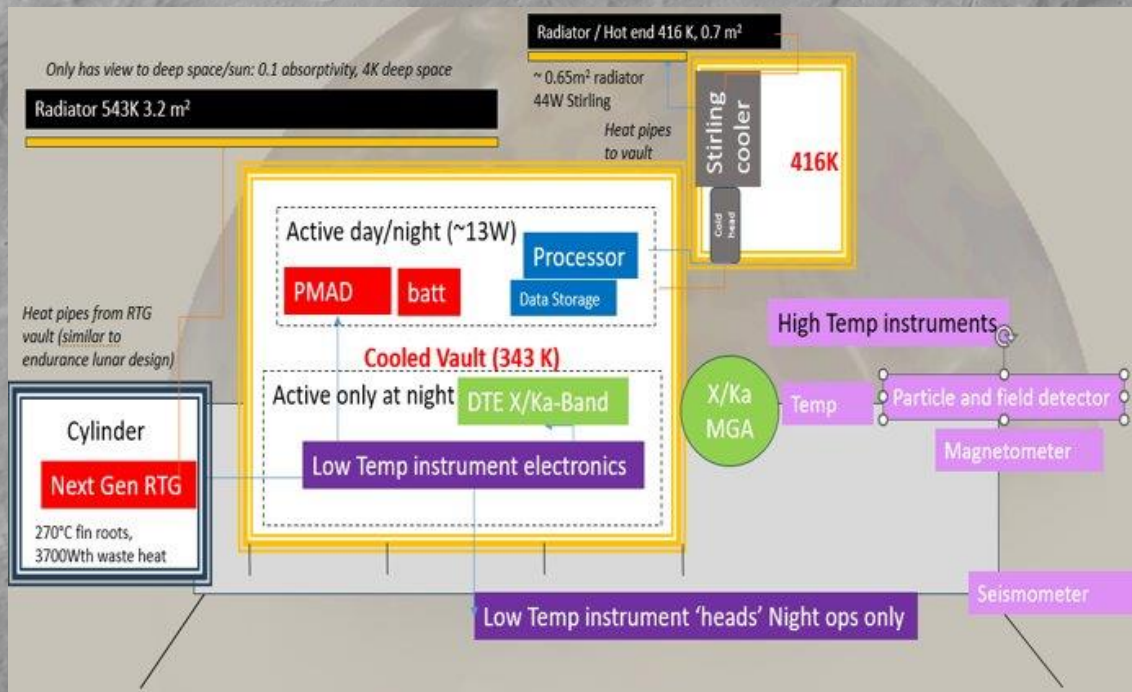
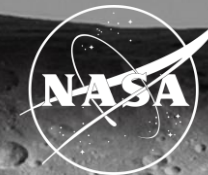


RTG / Electronics Vault Concepts for Mercury

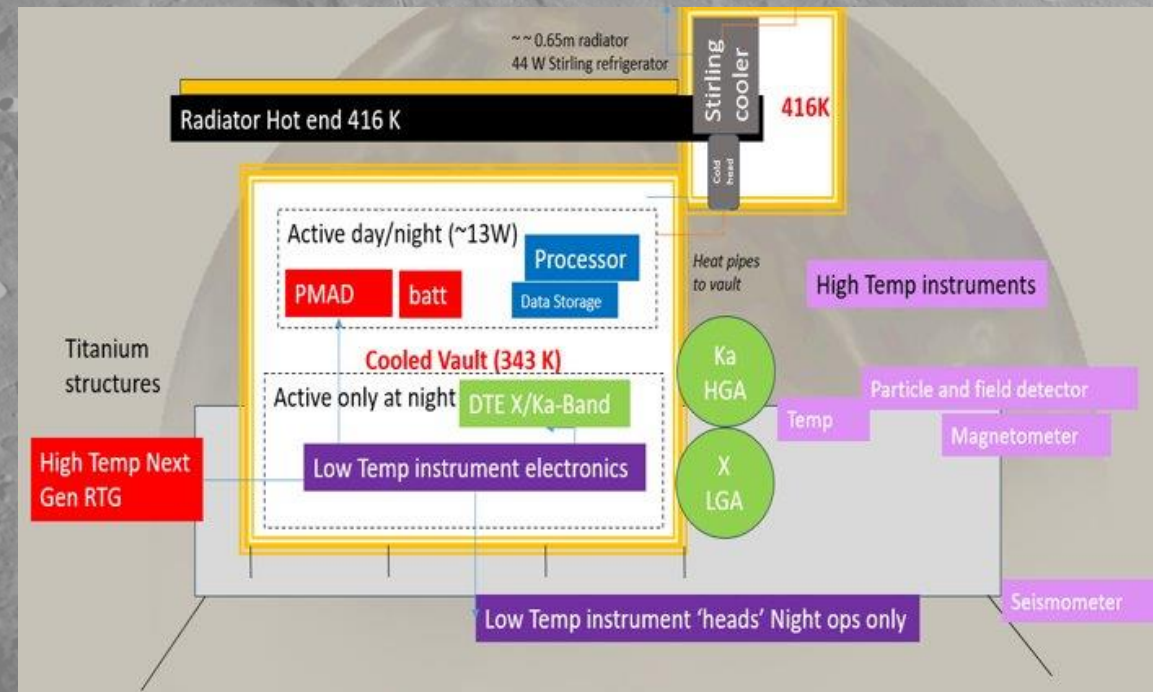
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Concept A – RTG in passively cooled vault, electronics in an actively cooled vault. Feasible in locations $>40^\circ$. ~150 kg increase in mass. Must accommodate 2 zenith facing radiators, one for standard electronics vault and another for RTG vault and Stirling cooler / vault for standard electronics



Concept B – Slight mods to RTG and Requalify (E.g. titanium structure vs aluminum, upgraded connectors). ~75 kg increase in mass. Must accommodate 1 zenith facing radiator and Stirling cooler / vault for standard electronics. Additional power for cooling electronics vault required below 40° .

Take Aways

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- At first order, there is reasonable plausibility for extending targeted science of a Mercury Lander mission for 2 or more Mercury years by incorporating maturing high-temperature systems and thermal management designs.
- The driving subsystems are power and payloads.
 - For payloads: several relevant high-temp sensors and instruments are feasible
 - For power: There are several approaches to enable RTG operations both day and night. This capability will have significant beneficial impacts to a multiyear lander.
 - With relatively low-risk modifications to the RTG (E.g. change structure to titanium, upgrade connectors) it would be able to operate at Mercury day temps. A delta qualification would be needed.
 - There are also approaches (using insulation, coatings, and shields) that do not require modifications to the current Next Gen RTG, applicable for latitudes $>40^\circ$.
 - Lander design will need to accommodate high-temp and thermal management hardware.
- Additional studies needed to work designs, secondary environmental effects, etc..
- Happy to work with teams to explore such concepts and designs