Mercury Scout

The Mercury Scout mission is a low-cost orbiter concept that will 1) map the silicate mineralogy of the surface using absorptions in the 4-8 micron wavelength region and 2) provide high-resolution visible wavelength images (meter scale). These two data sets will fill fundamental science knowledge gaps, and provide essential data for choosing sites for future landed missions.

__Summary__

Destination - Mercury

Platform - Orbiter

Science Goals – 1) Map silicate mineralogy of the surface, 2) obtain meter-scale visible wavelength images.

Mission Architecture and Size – Similar to Lunar Trailblazer, with increased thermal control and radiation toughness.

Expected Measurements – 1) 4-8 micron wavelength mapping, 2) visible wavelength images with meter-scale or better spatial resolution. Ideally could image both highly illuminated surfaces and permanently shadowed craters.

Target Solicitation – Discovery or SIMPLEx (descoped to just spectrometer).

__Technology Needs__

Mineralogy – Due to the unexpectedly low Fe content of silicate minerals on Mercury, no minerals were identified by the VNIR spectrometer on the MESSENGER mission. Recent work in the 4-7 micron wavelength region (IMIR – intermediate infrared) shows multiple absorptions for silicate minerals, including olivine and orthopyroxene that should be abundant on Mercury (Fig. 1). Importantly, the absorptions are present (and strongest) in low Fe minerals. This spectral region is uniquely well-suited for mapping the mineralogy of Mercury. Mineralogy is key to understanding the current distribution of geologic features, as well as the long-term chemical and physical evolution of the planet. It was one of the primary goals of the MESSENGER mission.

High-resolution imaging - Meter-scale (or better) imaging in visible wavelengths will provide a wealth of knowledge across a range of disciplines. Targets include fault scarps, hollows, polar ice deposits, high slope crater walls (landslides), pyroclastic deposits and fresh craters (to monitor space weathering). In addition to the science objectives, high-resolution images will provide essential information for selection of future landing sites.

Thermal control and radiation hardness – The proximity to the Sun requires the orbiter to have substantial thermal control capability and to be able to withstand high solar wind and radiation levels, including possible solar flares and CMEs.

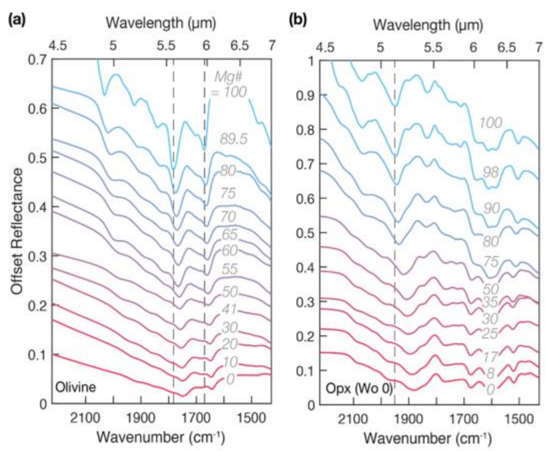

Figure 1. *IMIR spectra for a) olivine and b) orthopyroxene, as a function of Mg# (labels on spectra). Note that absorptions are strongest at low Fe. The same spectral features are seen in emission spectra. (Kremer et al, 2020).*

Propulsion – The propulsion system should minimize travel time and cost (including possible rideshare), and should provide the longest possible orbit duration. Long durations will allow 1) repeated spectral mapping to increase signal to noise, 2) increase the number of targets for the high resolution camera and 3) studies of surface evolution over extended time periods.

Current Technology Solutions

IMIR spectrometer – A high temperature IMIR spectrometer is being developed at JPL (Rob Green), based around a HOT BIRD (high operating temperature barrier infrared detector). Sensor material is HgCdTe (MCT). The detector is incorporated into the UCIS (ultra-compact imaging spectrometer), and is similar to the HVM3 spectrometer on the Lunar Trailblazer mission (Fig. 2). The spectrometer is at TRL 4 and meets the mission requirements for spectral range and thermal tolerance.

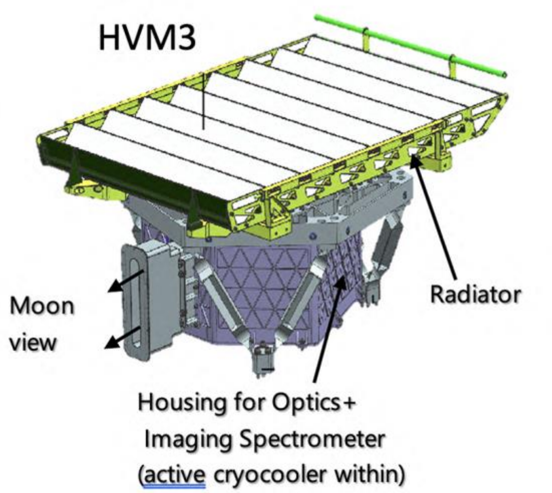

Figure 2. *HVM3 spectrometer for Lunar Trailblazer mission. The optical design of HVM3 is very similar to the IMIR spectrometer envisioned for Mercury Scout. (Ehlmann et al, 2022).*

High-resolution camera – No camera design has been selected at this point. It should have meter or better spatial resolution at a nominal orbit of 100 km, and should be stable at the high operating temperatures of Mercury's space environment.

Propulsion – A solar sail propulsion system fits the need of high delta V, low cost and long duration. With no delta V from the launch vehicle (rideshare), transit times would be ~5.3 years, assuming a solar sail similar in size to the one on the Solar Cruiser mission (Fig. 3, PI: Les Johnson). With a dedicated launch, transit times could be as low as 4 years. Once at Mercury, it takes ~50 days to maneuver the orbiter into a polar orbit (nominal altitude=100 km), and 176 days to map the surface. Because the solar sail will not run out of fuel, mission duration could be extended indefinitely. Use of a solar sail for orbiting will require gimbaling of all imaging systems to maintain pointing at the surface.

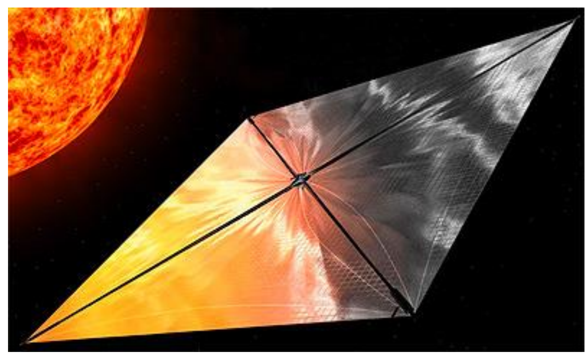

Figure 3. *Solar Cruiser mission (NASA: artist concept). The sail is ~1563 m^2 in area and is similar to the size needed for Mercury Scout (~2500m^2).*

Cost and Descoping – As described, the mission is likely in the low range of Discovery budgets. A descoped mission with just an IMIR spectrometer would fulfill the top science objective. If the launch option was a rideshare, the cost may fit in the SIMPLEx budget.

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