Mineralogical, Elemental, and Tomographic Reconnaissance Investigation for CLPS (METRIC): A Payload Designed for Exploration of Terrestrial Planetary Bodies

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Geological materials (indeed, all solid objects) are characterized by their crystal structure, elemental composition, and morphology. The Mineralogical, Elemental, and Tomographic Reconnaissance Investigation for CLPS (METRIC) instrument suite quantifies all three. These measurements address fundamental science questions (e.g., the origin and evolution of planetary bodies) and support the human exploration of space (e.g., the characterization of regolith for ISRU and the constraint of its geotechnical properties). METRIC comprises an X-ray Diffraction/X-ray Fluorescence instrument (XRD: mineral structure and XRF: elemental composition), an X-ray micro-Computed Tomography instrument (XCT: 3D internal micromorphology), and a hyperspectral imaging infrared spectrometer (IRS) to provide local/regional mineralogic context for these measurements. METRIC XRD/F draws heritage from the highly successful Mars Science Laboratory CheMin instrument. The METRIC XRD/F employs two separate sample cells, one optimized for XRD and one for XRF, resulting in more rapid XRD analysis (tens of minutes vs. tens of hours for CheMin) and an orders-of-magnitude improvement in XRF detection. XCT has not been deployed in space, so the METRIC XCT represents a new capability for solar system exploration. The XCT uses the same basic high-TRL components as METRIC XRD/F, decreasing its development cost for flight. The METRIC IRS is a derivative of the NASA Earth Science Technology Office funded Hyperspectral Thermal Imager instrument and utilizes the NASA Technology Transfer Program to incorporate a commercial-of-the-shelf infrared camera ruggedized for space by NASA Marshall Space Flight Center. The IRS spectral range (8–14 μm) and resolution (10.8 cm^{-1}) are tailored to quantify mineralogy in rocks using their characteristic Reststrahlen bands and to characterize mineralogy of soils using the position of the Christensen Feature.

The METRIC payload is currently designed for deployment to the Moon on a Commercial Lunar Payload Services (CLPS) mission, where the XRD/F and XCT would be located on a lander and the IRS would be on deployed on a companion rover to evaluate the mineralogical diversity of the landing site. A pneumatic drill designed by Honeybee Robotics would excavate regolith up to 50 cm below the lander and deliver multiple aliquots of regolith to the XRD/F and XCT. The METRIC payload could also be deployed on a rover. In this case, a sample handling system on a robotic arm could scoop regolith and/or drill rocks and deliver powder to the XRD/F and XCT located in the rover's interior. Alternatively, METRIC instruments could be used singly or in combination on human space missions. The XRD/F and XCT could be used to characterize samples in a rover or in a science laboratory within a habitat. These data could help astronauts identify resource-enriched rocks and regolith and triage geologic samples to return samples of high

interest for analysis in terrestrial laboratories. The IRS could be attached to a human-navigated rover to collect mineralogical data along a traverse and identify high-priority science samples.