The Volatiles Investigating Polar Exploration Rover (VIPER) Mission: Measurement Goals and Traverse Planning,

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Introduction: The Volatiles Investigation Polar Exploration Rover (VIPER) mission is a lunar polar volatiles prospecting mission developed through NASA's Planetary Science Divission with flight in late 2023 [1]. The mission includes a rover-borne payload that (1) can locate surface and near-subsurface volatiles, (2) excavate and analyze samples of the volatile-bearing regolith, and (3) demonstrate the form, extractability and usefulness of the materials. The primary mission goal for VIPER is to evaluate the In-Situ Resource Utilization (ISRU) potential of the lunar poles, and to determine their utility within future NASA and commercial spaceflight architectures. VIPER will be optimized for lunar regions that receive prolonged periods of sunlight (short lunar nights) to prospectively extend the total mission duration to more than 90 Earth days and to traverse as much as 20 km in distance. The VIPER payload includes three "prospecting instruments" - a neutron spectrometer, a near infrared spectrometer and thermal radiometer, and a mass spectrometer – all of which will be continuously functioning uring rover driving operations. VIPER also has a 1-meter drill that can excavate in 10 cm subsurface sample to be examined by the near infrared and mass spectrometers.

Measurement Goals and Traverse Design: A critical goal to both science and exploration is to understand the form and location of lunar polar volatiles. The lateral and vertical distributions of these volatiles inform us of the processes that control the emplacement and retention of these volatiles, as well as helping to formulate ISRU architectures. While significant progress has been made from orbital observations [2-6], measurements at a range of scales from centimeters to kilometers across the lunar surface are needed to generate adequate "volatile mineral models" for use in evaluating the resource potential of volatiles at the Moon. To this end the primary mission goals for VIPER are to (1) provide ground truth for models and orbital data sets, including temperatures at small scales, subsurface temperatures and regolith densities, surface hydration and hazards (rocks and slopes), (2) correlate surface environments and volatiles with orbital data sets to allow for better prediction of resource potential using orbital data sets, and (3) address key hypotheses regarding polar volatile sources and sinks, retention and distribution, key to developing economic models and identifying excavation sites.

The VIPER rover system was designed to be as simple as possible (low cost and risk) while still meeting these requirements. Detailed analyses of traverses, including rover models that include power, data and mobility models, has found that a solar powered rover with Direct to Earth (DTE) communications could meet all mission goals within one Lunar day (mission length 10-12 Earth days). Therefore, the simplest design utilizes only solar power with no radiogenic heating (e.g., Radioisotope Thermoelectric Generators or RHUs) or other non-solar power systems.

Polar Solar "Oases": Numerous studies have identified "oases"; regions near the lunar poles that have sustained periods of solar illumination (add citations?). In some 'oases', the periods of sustained sunlight extend across several lunations, while others have very short (24-48 hours) nights. While the Earth would set, as seen by the rover, approximately every 2-weeks, these "oases" could provide enough power, and have lunar-nights short enough, for the rover system to survive.

Multi-Lunar Day Mission Traverses: Several detailed traverse plans for VIPER have been developed to further help with rover development and to develop mission operational concepts (see Figure 1). The mission planning is organized into two phases, including an "early" phase during which rover traversing and observations follow as much of a pre-planned schedule as possible (with pre-planned anomaly mitigation plans) and "late" phase, during which more real-time decision making is implemented and reactions to "early phase" findings are enabled. Both phases take advantage of the near real-time communications with the rover and real-time geostatistical analysis methods to maximize observation effectiveness.

References:

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