NASA lunar robotic science missions support the high-priority goals identified in the 2007 National Research Council report, The Scientific Context for Exploration of the Moon: Final Report (http://www.nap.edu/catalog.php?record_id=11954) Space-qualified instruments perform remote and in situ lunar science investigations, to include measurements of micrometeoroid and lunar secondary ejecta environment, lunar dust composition, reactivity and transport, searching for water ice, assessing the radiation environment, gathering long period measurements of the lunar exosphere, and conducting surface and subsurface geophysical measurements. Improving science return and/or reducing mass, power, volume, or data rates is desired.

In support of these requirements, this subtopic seeks advancements in the following areas:

**Geophysical Measurements**

Systems, subsystems, and components for seismometers and heat flow sensors capable of long-term continuous operation over multiple lunar day/night cycles with improved sensitivity at lower mass and reduced power consumption compared to the Apollo Lunar Surface Experiments Package (ALSEP) instruments (http://www.hq.nasa.gov/alsj/frame.html). Instrument deployment options include robotic deployment from soft landers, as well as emplacement by hard landers or penetrators. Also of interest are portable surface ground penetrating radars with antenna frequencies of 250-MHz, 500-MHz, and 1000-MHz to characterize the thickness of the lunar regolith. Also of interest are accurate, low mass, thermally stable hollow cubes and retroreflector array assemblies for lunar surface laser ranging.

**In Situ Lunar Surface Measurements**

Light-weight and power efficient instruments that enable elemental and/or mineralogy analysis using techniques such as high-sensitivity X-ray and UV-fluorescence spectrometers, UV/fluorescence flash lamp/camera systems, scanning electron microscopy with chemical analysis capability; time-of-flight mass spectrometry, gas chromatography and tunable diode laser (TDL) sensors for in situ isotopic and elemental analysis of evolved volatiles, calorimetry, Laser-Raman Spectroscopy, Imaging Spectroscopy, and Laser Induced Breakdown Spectroscopy (LIBS). Instruments shall have the potential to provide isotope ratio measurements and/or hydrogen distributions to ±10 ppm locally. Characterizing the meteoroid and subsequent eject flux environment and measurements of surface and deep dielectric charging on the lunar surface should be considered. Also, self-
calibrating instruments to measure surface and deep dielectric charging on a variety of materials encompassing conductors, semi-conductors, and insulators are another area. Instrument deployment options include robotic deployment from soft Landers, as well as emplacement by hard Landers or penetrators.

**Lunar Atmosphere and Dust Environment Measurements**

Low-mass and low-power instruments that measure the local lunar surface environment which includes but is not limited to the characterization of: micrometeoroid and lunar secondary ejecta environment, the plasma environment, surface electric field, secondary radiation at the lunar surface, and dust concentrations and its diurnal dynamics. Instrument deployment options include robotic deployment from soft Landers, as well as emplacement by hard Landers or penetrators.

**Lunar Regolith Particle Analysis**

A substantial portion of the particles in the Lunar Regolith are smaller than the integration volume of e-beam analytical equipment, making automated quantitative analysis extremely difficult using available approaches. Other techniques for obtaining particle analysis are desired. Example techniques include optical interrogation or software development that would automate integration of suites of multiple Back Scatter Electron images acquired at different operating conditions, as well as permit integration of other data such as cathodoluminescence and energy-dispersive x-ray analysis. The said software would then use standard image processing tools to resample to common scales, perform appropriate discriminant analysis using the high resolution data, mixed pixel inversion, image segmentation to extract particles, and correlate chemistry with products of the discriminant analysis.

Research should be conducted to demonstrate technical feasibility during Phase I and show a path toward a Phase II hardware and software demonstration, and when possible, deliver a demonstration unit or software package for NASA testing at the completion of the Phase II contract.