*Summary*: Observe the sun, its corona and space weather with an optical/UV telescope, magnetometers; plasma and radio wave instruments; and plasma analyzer. Understand the effects of the Moon passing through the Earth's geomagnetic tail.

*Value*: Provide information relevant to solar events and their effect on earth, and also on the hazards presented by solar storms on long-duration space flight (ie. going to Mars)

*Science topic*: The atmosphereless Moon is immersed in the plasma/energetic particle environment of the heliosphere, and thus space weather will impact the productivity and safety of lunar robotic and human exploration. In particular, the radiation from intense Solar Energetic Particles (SEP) events will interact with the material of spacecraft, the components of the spacecraft control systems, space habitats, space suits, and the bodies of crew members. At present, we do not understand the mechanism for the onset of coronal mass ejections or solar flares, nor the physics of energetic particle acceleration and why certain coronal mass ejections (CMEs) or solar flares produce intense SEP events. Current and future SMD missions will address these questions. The current Solar Terrestrial Probe (STP) STEREO and Solar-B missions and future Living With a Star (LWS) Solar Dynamics Observatory (SDO), Radiation Belt Storm Probe (RBSP) missions and the Solar Sentinels mission concept will develop the physical understanding necessary to reliably model and predict the radiation environment at one AU and understand the dominant mechanisms associated with energization of particles that produce harmful radiation. This information can then be used to specify the physics-based space environment models and the operational space monitoring system required to reliably predicting space weather in support of mission operations (both human and robotic) in the lunar environment.

The interaction of solar wind and distant geospace plasmas and energetic particles with the lunar surface often produces large surface electric fields (analogous to spacecraft charging) with total potentials up to many kilovolts negative (remotely sensed by Lunar Prospector; Halekas et al, 2005), especially in the shadowed regions immersed in energetic plasma. These fields may be hazardous, and they are certainly important for transport of dust, another possible hazard. In sunlight, where photo-emission dominates, the surface potential is typically tens of volts positive, so very large electric fields are likely to be present at the day-night terminator. These interactions are not well understood; for example, it is found that the largest potentials occur in SEP events (Halekas et al, 2006).

The solar wind colliding with the Moon producing a ion-free cavity behind, but solar wind electrons traveling along the magnetic field (generally not parallel to the solar wind) can enter the cavity, so very large charge separation electric fields are produced at the solar wind terminator that may also be important. The evolution of these plasma interactions often produces a variety of intense waves and beams.

*Methodology Description*: To significantly improve forecasting of the hazardous intense SEP events, the STP STEREO and Solar-B and LWS SDO, RBSP and Sentinels mission will be needed. STEREO will provide understanding of the development of CMEs and Solar-B will provide insight to the onset of explosive events on the Sun Surface. ITSP will explore acceleration processes within the Earth's magnetosphere and the LWS Sentinels as currently envisioned will provide multi-point measurements in the inner heliosphere (0.25 - 0.75 AU) to directly study the SEP acceleration process free of the blurring effects of particle scattering and propagation (see http://sentinels.gsfc.nasa.gov/ for Sentinels report) . Overlap with the LWS Solar Dynamics Observatory mission, presently being developed for a 2008 launch would provide simultaneous detailed optical/EUV/X-ray imaging and diagnostics of the Sun to determine the initiation of the CMEs/flares that produce SEPs, and their characteristics.

Comprehensive measurements of the plasma/energetic particle and fields environment close to the Moon are needed to understand the large electric fields and their origins. Such detailed comprehensive measurements of the near-lunar surface environment have never obtained before. A small low (<~100 km) lunar-orbiting spacecraft with a comprehensive set of plasma, energetic particles, electric and magnetic fields, waves, and composition measurements would be needed, together with surface measurements in many locations (see the dust objective for surface instrumentation).

For an operational and monitoring system for space weather in the lunar environment, multiple observations are needed; these include solar imaging, in situ L1 solar wind measurements and lunar orbiting and surface measurements. In preparation for future operational and monitoring of the radiation environment at Mars, a ring of small s/c arrayed around the Sun at 1 AU would provide needed input.

*Instrumentation*:
For lunar orbiting spacecraft:

| | Mass | Power | Telemetry | Heritage |
|---|---|---|---|---|
| Full 3-D Plasma ion and electron sensors | 3 kg | 3 W | 2kbps | THEMIS |
| Energetic ion and electron sensors, covering from just above plasma energies up to >~100 MeV. | 3 kg | 4 W | 1kbps | WIND |
| 3-D Electric Field instrument | 10 kg | 5W | 2kbps | THEMIS |
| Magnetometer | 1 kg | 1W | 1kbps | THEMIS |
| Plasma Waves instrument | 3 kg | 3W | 1kbps | FAST |
| Ion composition instrument(highly desirable) | 4 kg | 4W | 1kbps | FAST |

For surface instrumentation, see dust objective.
For Solar Sentinel instrumentation and other LWS missions, see www.lws.gsfc.nasa.gov/

*Human Involvement*: For the surface instruments, humans to put the instrument in appropriate locations and to move them around as needed would be highly desirable.

*Timing*: LWS SDO, RBSP and Sentinels – before human return to the Moon, to determine operational requirements.

Lunar plasma orbiter – early robotic phase for assessment of electric fields and dust hazards.

Lunar surface instrumentation – early robotic and early human phase to establish operational guidelines.

*Experiment features and Benefits*: Possibly useful for resource mapping.

*References*:

Halekas, J. S.; Lin, R. P.; Mitchell, D. L., Large negative lunar surface potentials in sunlight and shadow, Geophysical Research Letters, Volume 32, Issue 9, CiteID L09102, 2005.

Halekas, Jasper S.; Delory, G. T.; Mewaldt, R. A.; Lin, R. P.; Fillingim, M. O.; Brain, D. A.; Lee, C. O.; Stubbs, T. J.; Farrell, W. M.; Hudson, M. K., Lunar Surface Charging during Solar Energetic Particle Events, submitted to Geophysical Research Letters, 2006.