OPTIMIZING INSTRUMENT PACKAGES FOR THE LUNAR SURFACE. P.E. Clark[1], R. Lewis[2], and L. Leshin[2] [1]Catholic University of America (Physics Department) at NASA/GSFC, Code 695, NASA/GSFC, Greenbelt, MD 20771, Pamela.E.Clark@NASA.GOV; [2]NASA/GSFC, Greenbelt, MD 20771.

Introduction: In support of NASA's Lunar Architecture Team (LAT) activities to devise and plan lunar mission infrastructure options, a science and engineering team at GSFC has conceptualized and investigated several lunar surface science and carrier packages. These studies have demonstrated that when conventional approaches are used in designing instrument packages, performance suffers and mass and cost parameters grow significantly as a result of increased thermal protection and battery power requirements necessary to withstand lunar environmental conditions within needed operational constraints.

Instrument packages under consideration: Three packages have undergone preliminary system and subsystem design using a conventional instrument package design approach at the GSFC ISAL (Instrument Systems Analysis Laboratory) facility. These include an lunar environmental monitoring station (LEMS) and an unpressurized carrier, as shown in Figures 1 and 2, as well as a small Earth Observing telescope package.

The carrier is designed as a reusable unpressurized cargo carrier. It would have a thermostatically controlled environment and capability for survival power up to 48 hours as well as connectivity for external power and monitoring.

LEMS is designed to provide detailed measurements and comprehensive understanding of the interactions between radiation, plasma, solar wind, magnetic and electrical fields, exosphere, dust and regolith. It is not only representative of automated lunar science stations which would provide a much needed context for in depth understanding of the Moon, and is a primary candidate for early deployment before contamination of the lunar exosphere. Thus LEMS would provide critical data on space weather and medium- to long-term trends in the lunar surface environment. The instrument package consists of spectrometers to measure neutral gas species of the exosphere, X- and Gamma-radiation, energetic neutrons and protons from the solar and galactic radiation environment; particle analyzers to measure the spatial and energetic distribution of electrons and ions; a dust experiment to measure diurnal variations in the size, spatial, and velocity of lunar and micrometeorite dust; and electric and magnetic field instruments to indicate changes resulting from variations in solar activity, and terrestrial magnetic field interactions.

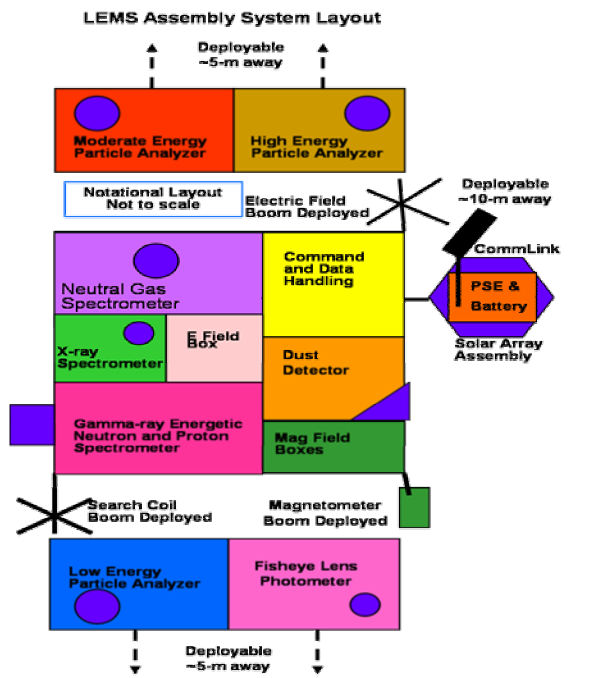
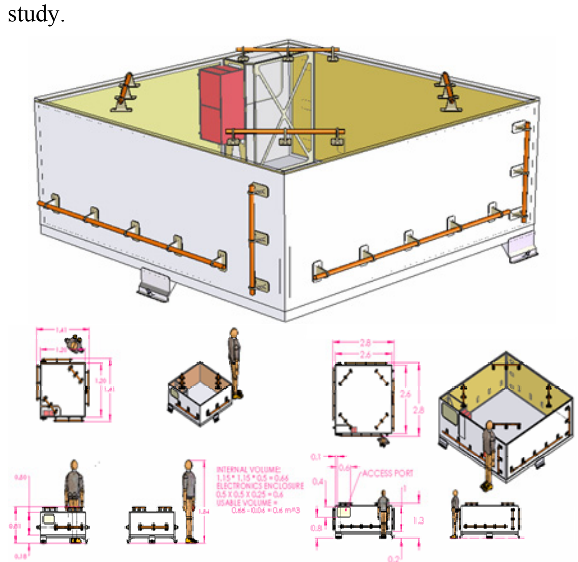


Figure 1: Schematic of one of Lunar Environmental Monitoring Station (LEMS) above and unpressurized carrier concept below under consideration as part of this study.



Using a Conventional Design Approach: Both LEMS and the observatory package are designed to be an automated stations powered by solar panels with batteries, and operational for up to five years. The stations must survive the extreme cold and thermal cycling varying between the poles and equator (50K to 400K) as well as prolonged darkness over periods ranging from five days to 14 days. These lunar surface conditions are quite different from conventional deep space conditions where one side of the spacecraft is almost always illuminated and heat dissipation is the thermal issue.

In fact, when conventional approaches were used to design the LEMS package, for example, battery mass driven by the need for power for survival heaters during periods of prolonged darkness became the overwhelming driver of the total mass with only 19% allocated for the instrument payload and 53% for the power system. The power allocation was 180W (85W for the instruments) during the day, 90W (60W for thermal heaters alone) at night with the instruments turned off, even though measurements made during periods of darkness are essential.

Need for an alternative Design Strategy: Clearly, strategies which reduce the need for thermal survival, an issue particularly in minimal atmosphere surface environments with long periods of low to no illumination, through the use of ultra-low power, ultra-cold operating components that are now becoming available, and the use of thermal design and innovative thermal balance strategies are crucial to design a package with mass, power, and volume significantly reduced to create opportunities for more science packages.

We are in the process of developing a systematic approach to applying ultra-low power and ultra-low temperature technologies, and test this approach by applying it to a Goddard Space Flight Center (GSFC) science instrument package concept considered a near-term contender for implementation. Our strategy will incorporate components and design concepts which radically minimize power, mass, and cost while maximizing the performance under extreme cold and dark conditions even more demanding than those routinely experienced by spacecraft in deep space. In this way, instrument system and subsystem design, packaging, and integration will significantly enhance the opportunities for the science community to develop selectable, competitive science payloads.

Promising Technologies for operating on Cold, Dark Surfaces: Ultra-low power and low temperature (ULP, ULT) strategies, some developed at GSFC and through partnerships with the University of Idaho and the Department of Defense (DoD) National Reconnaissance Office (NRO), are being used successfully and have demonstrated orders of magnitude savings in power consumption and thermal tolerance. These systems include the use of CULPRiT (CMOS Ultra-low Power Radiation Tolerant) technology successfully flown on NASA's ST5 90 day mission in March 2006.

Attempt to develop a new design strategy: Important aspects of our ongoing work are:

1) To conduct a comparative analysis of GSFC's low temperature/low power and packaging strategies (e.g., CULPRiT and others) and conventional power and mass reducing strategies as applied to a lunar surface instrument package (Lunar Environmental Monitoring Station) which has already undergone preliminary study identifying the most promising components and design strategies for the candidate systems. Low temperature and low power electronics coupled with thermal design packaging will be studied. A full system design approach will be instituted;

2) To develop system design concept guidelines and a "toolkit" exemplified by application to one or more candidate GSFC instrument packages under development for the lunar surface; and

3) To develop a plan for advancing recommended technologies in application to lunar surface instruments, payloads, and associated systems to minimize mass, volume, and power requirements as a precursor to design guideline generation.

This approach will leverage NASA's existing and projected unique capabilities within the creation and implementation of these technologies that are critically in demand to serve NASA's Vision for Exploration.

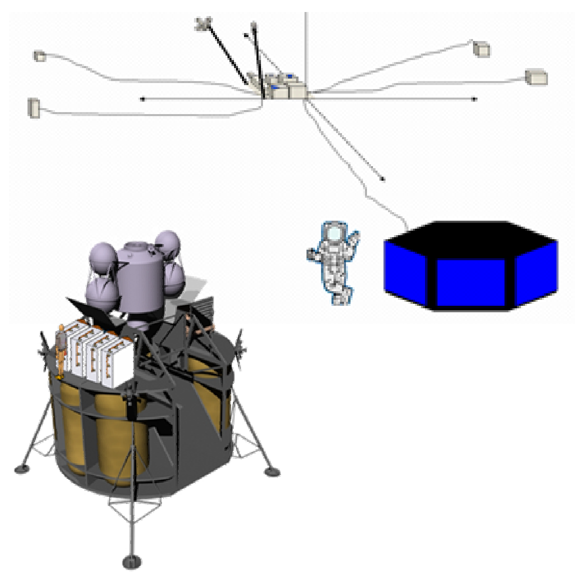


Figure 2: Schematic of deployed LEMS in background with astronaut standing by solar panel/battery assembly in mid-ground and Lander with carrier on top deck in foreground.