Lunar Mission Operations

I. SAFETY- Health and safety Issues

II. MISSION OPS ISSUES

Geodetic Control

Produce a cartographic control network so that surface position is known accurately to 100 m spatial, 1 m vertical.

Minimum requirement:
+ - 100 meters

This will permit the precise location of interesting features to be known and will aid in pin point landings to visit such sites.

This knowledge is intrinsically linked to obtaining a high resolution shape model for the Moon.

Current knowledge: Large farside errors positional errors exist. Errors greater than 13 km on the farside and better than a few 100 metres close to the Apollo sites.

Global Topography

Obtain global contiguous topography of lunar surface at a spatial resolution of 100 m and with a vertical precision of 1 m.

Swaths with greater precision? (i.e. potential landing sites)
Where are these? What resolution should they be?
What are requirements for exploration sorties/traverses?

Global topography is required in order to produce a cartographic network for the Moon. It is also required for mission planning. Elevation of a landing site is required in designing a lander mission. Topography combined with gravity measurements provides an insight into the internal structure of the Moon. Topography permits photometric correction of broad scale imaging data.

Current Knowledge: Between 65° N and 65° S topography produced using Clementine LIDAR with 75 km/pixel spatial and 100 m vertical errors. Polar region topography produced from Clementine stereo and nearside radar measurements. Absolute altitude of both poles is not known.

Gravity

Know the position of the spacecraft to 100 m along/across track and 1 meter radius

Improved farside gravity is particularly important as it permits knowledge of s/c orbit which directly improves other measurements such as topography.

Current Knowledge of gravity field:
tbd

Radiation Environment

Determine the ionizing radiation environment in lunar orbit and on the lunar surface. Measurements require simultaneous monitoring of the ionizing radiation in lunar orbit and at the surface. Required for crew health and safety.

Measure charged particle spectra, simultaneously at the surface and in orbit, accumulated absorbed dose and dose rate in a tissue-equivalent material as a function of time over time.

Determine the linear energy transfer spectrum from 0.1 keV/um to 1500 keV/um, and separate the contributions of protons, neutrons, and HZE particles to these quantities simultaneously at the surface and in orbit.

Measure neutron energy spectrum from 100 keV to 50 MeV or above. Provide the capability to distinguish between incident and albedo neutrons at the surface to determine the backscatter effects of the lunar regolith.

Recurring requirement to support future human missions

Life Science experiment options:
- Tissue experiments
- Small payload

(Safety and navigation)

Global Morphology Characterization

Global data set obtained at 15-20 m/pixel with low Sun angles (15-30°). High priority regions imaged at 50 cm/pixel. Imaging system tbd

Images taken with a low Sun angle provide information of the morphology of the surface. Co-registering these data with other data sets permits the investigation of correlations between composition and geologic features. Permits an examination of surface roughness. These type of images can be used for crater counting studies.

The high resolution images will enable rocks of the order of 1 m to be seen. Knowledge of their position will help in planning a safe precision landing.

Current data: Best morphology data set is the Lunar Orbiter photographs. X% of the lunar surface at 300 m/pixel with varying quality ranging from excellent to muddy.

Concurrent visual albedo and morphology at same scale

Mapping of Polar Resources

Determine the location and quantity of volatile resources in the polar regions.

Knowledge of the location of enhanced hydrogen deposits, or volatile deposits will enable planning of a lander mission to measure exactly what form these resources take. Correlations between resources and permanently shadowed regions may provide information as to the nature of the deposits. Requirement to map the lighting conditions in space and time in order to determine potential locations containing resources.

Current Knowledge: Hydrogen maps from Lunar Prospector are ~ 30 km/pixel. Clementine bistatic experiment suggests ice deposits in the south polar region.

Temperature Maps

Measure the temperature in the upper few centimeters of the regolith in the polar regions. The Probable temperature range to be measured is 30-300 with a 5 K precision desired.

Knowledge of the temperature has a direct implication on the ability of volatiles to exist in the in the permanently shadowed regions. Also provides engineering constraints on machinery to function inside these dark areas.

Current Knowledge: Temperatures in the permanently shadowed regions have not been directly measured. Modeling predicts the temperatures to be ~50 K

High Resolution Topography

Collect high resolution topography of selected areas, better than 10 m spatial and 10-20 cm vertical.

High resolution topography provides insight into the geology of interesting features such as central peaks. It also permits accurate photometric correction of images of these features by providing information on local slopes.

Design locations and measurement requirements for surface operations exploration

ISRU location

Mineralogical Mapping

Identify minerals with species and abundances +/- 5% relative precision at a spatial resolution of 15-20 m/pixel.

Detailed spectral coverage of the lunar surface will provide information on possible resources for future exploitation.

Global coverage but not necessarily global sampling. (Most lunar geologic units are homogenous over many km. Measurements needed for units -- not necessarily entire unit at 20 meters, permitting characterization of small, fresh features.)

Element Maps

Map the concentration of key elements including Mg and Al at a spatial resolution of 60 km/pixel.

Global contiguous units

Specify 10% relative precision

(Dependent upon orbital inclination)

Regolith Studies

Determine the structure of the upper 10 m of the regolith.

The goal is to understand the physical properties of the regolith to better plan its potential for utilization. Questions to be answered include how "unconsolidated" is the regolith, what is the block population, cohesiveness, porosity, density, thermal conductivity, tensile strength? How do any of these parameters vary with depth?

What can we realistically do?

Synoptic Imaging of the Lunar Poles

Image the 5° latitude region around each pole once every 5 hours during all illumination seasonal conditions.

The goal is to map out the illumination conditions near each pole. FOV is more important than spatial resolution for this study. Mapping every 5 hours corresponds to a change in lighting direction of 2.5°. In order to map through all possible illumination conditions this task will take between 6 months and a year depending on the time of year on arrival.

Current Knowledge: Clementine imaged within 2° of each pole once every 10 hours for 71 days during winter in the southern hemisphere.

Polar lighting /regions (add)

Magnetic Field Studies

Map the lunar magnetic field at a precision of 1nT globally at a spatial resolution of 10 km.

Areas with high magnetic anomalies are of interest for human exploration as they may represent safe haven in case of a dangerous solar event.

Atmospheric study

Analyze the vertical atmospheric profile distribution as a function of latitude.

These data provide information on volatile transport across the lunar surface.

Electric Field

Measure the surface electric current.

This will provide information on dust suspension and transportation which may have an effect on surface operations.