PROBING LUNAR LAVATUBE CAVES BY RADAR ILLUMINATION. Tom Billings[1] and Ed Godshalk[2], [1]Oregon L5 Society , P.O. Box 42467, Portland OR 97242-0467, USA (itsd1@teleport.com), [2]Oregon L5 Society , P.O. Box 42467, Portland OR 97242-0467, USA (edg@mixim.com).

A Radar Flashbulb on the Moon

Lavatube caves under the lunar surface may be very useful as lunar base sites. They have left surface indicators that can be found in computerized searches of the Clementine data. Such a search is being put together by the Lunar Base Research Team (LBRT) of the Oregon L-5 Society, Portland's local chapter of National Space Society.

Lavatube sites that are located will bear much further investigation before committment to a lunar base there. Ground-penetrating radar images of actual voids at particular sites seem the next step, if images can be obtained cheaply. This paper describes what LBRT believes is the cheapest combination of technologies that can obtain such images of lavatube voids on the Moon.

As early as the Apollo Lunar Sounder Experiment, radar has penetrated the Moon to substantial depths. Only soundings were possible given the combination of penetrating wavelengths (1-20 meters) and the aperture of any antenna that could be carried by the Apollo Service Module. Now, operation of the Very Long Baseline Array (VLBA) by NRAO provides an aperture that, even from the Earth, could provide a resolution of 25-50 meters at the lunar surface with wavelengths of .5m-1 m. The Lunar Sourcebook notes that much of the lunar surface is rather transparent to radio waves, because of it's low conductivity, and lack of water. Lavatube surface indicators have been found in Apollo photos for caves up to 1100 meters across. But where is the radar energy reflecting off the walls of these lavatube voids to come from?

The 4th power range coefficient in the denominator of the Radar Equation makes this extremely costly if the rf source is on Earth. Likewise, transport to lunar orbit of a powerful rf source is beyond any present budgetary reality. However, if we are investigating only the immediate areas around sites found by the Clementine data search, then a very localized rf source, of appropriate power and wavelength, becomes useful. Such a localized source would give a signal/noise ratio governed by a 2nd power range coefficient in the Radar Equation. This factor, combined with the resolution of the VLBA may make a cheap mission possible.

We would propose that unconventional rf sources can be placed close to some lavatube sites located by lunar surface indicators for far less than an orbiting rf source would cost. A free falling object launched from Earth would posess much kinetic energy at the lunar surface. Converting a large portion of that kinetic energy to rf energy is possible with a two-part probe shaped like 2 extended concentric metal cylinders that slide past each other as the forward cylinder's end strikes the lunar surface. By allowing a strong magnetic field to brake the rearward cylinder's motion, very large electrical currents can be generated in the second cylinder. These large currents would have to be conditioned and turned into appropriate wavelength rf energy, then radiated into the local lunar surface very rapidly.

Other conversion schemes are possible, including those using changes in electrical fields, or the compression of an rf standing wave of the desired frequency inside a resonant superconducting cavity. We believe that the magnetic field system can be demonstrated first.

At a 2.35 km/sec. impact speed, the probe would have less than 1/1000th of a second to "flash" the lunar surface with rf energy before the transmitter and power conditioners at the back of the probe smash into the surface themseves. If it can "flash" successfully, then the rf energy can penetrate the dry lunar surface, reflecting off large discontinuities within the lunar material, including the voids of lavatube caves in the local area.

That rf signal would bounce back to Earth and be picked up by the receivers of the VLBA. Processing of the received signal should allow us to discern which local sites do in fact have lavatube caverns and characterisics such as overburden, width, depth and length. Characteristics such as ice within the lavatubes might be determined by sophisticated analysis. Lavatube ice caves are common in the Pacific Northwest.

The mass of the probe will be determined by the energy requirements for penetration at a given wavelength and for reception at the VLBA, as well as the total efficiency of conversion from kinetic energy to rf energy. Each probe's "flash" may be able to illuminate strata for as much as a few kilometers around the probe impact site. This may allow several voids to be confirmed, or even newly found, from one probe. The observation time for the VLBA will be short enough to not intrude much on the normal VLBA observation schedule. This should allow small enough "flashbulb" probes to be sent along with other lunar missions on a "mass-budget available" basis.

If a special lunar mission is set aside for these probes, then timing of individual impacts might be made provisional by selecting a figure-8 trajectory passing close to both Earth and Moon that would return the spacecraft "bus" to a release window once each month. Kicking the next small probe out at a slightly different time, with a slightly different push during that window could change the impact point on the Moon and allow a wide range of sites on the Moon to be sampled by these probe's. If there is sufficient excess capability available on a commercial comsat launch, then a small package with it's own booster might "piggyback" to GTO. From there the delta-v requirements for lunar impact are much reduced. Multiple launch opportunities might be available over some years for a continuing program of exploration with this basic flight concept.

When sites ouside the Moon's nearside features are to be investigated, a phase II sensor array might be made available using arrays of small "nanosats" in a free-flying radar interferometer. If an array is to serve many seperate 'flashbulb' illuminations of the Moon, or Mercury, or even Mars, then an array of long-term satellites would be appropriate. If a 'single-shot' opportunity is being taken at one target on the Moon, or on a Near-Earth-Asteroid then very small devices making up an array may be viable. In each case, the smaller range to the target will allow greater resolution for the same wavelength, as well as new opportunities.