significant amounts of highly structured clay and evaporites within a predominately amorphous matrix.

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ONBOARD SIGNAL PROCESSING: WAVE OF THE FUTURE FOR PLANETARY RADIO SCIENCE? E. A. Marouf, Department of Electrical Engineering, San Jose State University, San Jose CA 95192-0084, USA.

Future spacecraft-based radio observations of planetary surfaces, rings, and atmospheres could significantly benefit from recent technological advances in real-time digital signal processing (DSP) hardware. Traditionally, the radio observations have been carried out in a "downlink" configuration in which about 20-W spacecraft-transmitted RF power illuminates the target of interest and the perturbed signal is collected at an Earth receiving station. The downlink configuration was dictated by the large throughput of received data, corresponding to a relatively large recording band width (about 50 kHz) needed to capture the coherent and scattered signal components in the presence of trajectory, ephemeris, and measurement uncertainties. An alternative "uplink" configuration in which powerful Earth-based radio transmitters (20–200 kW) are used to illuminate the target and data are recorded onboard a spacecraft could enhance the measurements' signal-to-noise ratio by a factor of about 1000, allowing a quantum leap in scientific capabilities. The recorded data must be preprocessed to reduce its volume while preserving its salient information content. The latter include time-history of estimates of the amplitude and phase of the coherent signal and dynamic power spectra of the scattered signal, computed at adaptable resolutions. The "compressed" data is later relayed to the Earth for further detailed processing and analysis. Onboard data compression can readily be accomplished either by a DSP processor that is a part of an Uplink Radio Science Instrument, or by a configurable spacecraft "DSP subsystem" that serves as a preprocessing engine for multiple spacecraft instruments. In either case, the hardware architecture must be sufficiently flexible to allow implementation of a broad class of preprocessing algorithms, adaptable to a given observation geometry and corresponding signal dynamics. Specific signal compression needs and expected scientific gain are illustrated for potential future uplink observation of planetary ring systems. A similar argument can be made for radio observations of the tenuous atmosphere of Pluto and for radio imaging of the martian surface, two potential targets for the Pluto FFM and the Mars MESUR missions.

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SPACEBORNE PASSIVE RADIATIVE COOLER. S. Mathias, Arthur D. Little, Inc., Cambridge MA 02140, USA.

Radiative coolers are passive refrigeration devices for satellites and space probes that provide refrigeration for an infrared or other type of detector that operates at cryogenic temperatures. Typically a cooler can supply 20 mW of cooling at about 85 K, and over 500 mW of cooling at about 165 K. The exact cooler temperatures and heat loads are dependent upon the clear field of view of the cooler to space.

Some features of the Arthur D. Little passive radiative cooler are (1) the cooler has no moving parts leading to very long life and high reliability; (2) the cooler weight is approximately 3 lb; (3) the detector may be easily replaced without disassembling the cooler; (4) the alignment of the detector is insensitive to induced launch vibration and thermal cycling; (5) a movable field lens provides a simple method of adjusting the system focus during testing at operating temperatures; (6) the optical axis is referenced to the room-temperature mounting flange interface, eliminating the need for iterative optical adjustments in thermal vacuum chambers at the system level; (7) heater and temperature sensors provide precise detector temperature control; (8) the design offers protection against overheating of the sensitive detector element during nonoperational spacecraft attitude acquisition; (9) a modular "bolt-on" concept provides simple integration and interface definition of the cooler with an optical system; and (10) there is maximum protection of the low-temperature optical elements from contamination.

N93-28803

SYSTEMATIC PROCESSING OF CLEMENTINE DATA FOR SCIENTIFIC ANALYSES. A. S. McEwen, U.S. Geological Survey, Flagstaff AZ 86001, USA.

If fully successful, the Clementine mission will return about 3,000,000 lunar images and more than 5000 images of Geographos. Effective scientific analyses of such large datasets require systematic processing efforts. Described below are concepts for two such efforts.

Global Multispectral Imaging of the Moon: The lunar orbit has been designed to enable global coverage with the UV/VIS and near-IR cameras. Global coverage will require 120 frames per orbit × 300 orbits × 16 frames (6 near-IR filters and double coverage in 5 UV/VIS filters to improve S:N), for a total of 576,000 image frames. Lunar scientists cannot analyze half a million small images. We will need a single global 11-wavelength image cube with full geometric and radiometric calibrations and photometric normalizations. Processing steps could include (1) decompressing the data, (2) radiometric calibration, (3) removal of camera distortions, (4) co-registration of each set of 16 images to 0.2 pixel, (5) replacing bad or missing data, (6) merging UV/VIS double coverage, (7) identifying three control points per orbit, (8) along-track frame matching (geometry and brightness), (9) reprojecting images, (10) photometric function normalization, (11) mosaicking into single-orbit strips, (12) brightness matching of orbit strips, and (13) mosaicking orbit strips into map quadrangles. The final global dataset at a scale of 100 m/pixel will require a set of 70 CD-ROMS (650 Mbytes/CD) for archiving and distribution. Once systematic processing is completed, a series of global maps can be derived that show the distribution and abundances of pyroxenes, olivine, anorthosite, shocked anorthosite, norite, troctolite, glassy materials, and titanium.

Videos of Geographos: Clementine is expected to acquire continuous imaging throughout the closest approach sequence at Geographos with frame rates of 4.5 or 9 frames/s. (For comparison, the highest frame rate on Galileo is 0.4 frame/s, and there was no imaging near closest approach to Gaspra.) The high frame rates and continuous imaging are ideal for production of computer "movies" of the flyby, which can be recorded onto video tapes. These movies will consist of actual observations, rather than simulated sequences generated from a shape model. They will enable the viewer to see all the details of the topography, morphology, and distribution of compositional units as the viewing and illumination geometries change. Several different video sequences of Geographos are anticipated, including separate sequences for each imaging system and merged datasets. The LIDAR will provide the highest spatial resolutions (in four colors), the thermal-IR detector will provide nightside imaging, the UV/VIS camera will provide the highest resolution of the entire visible and illuminated surface during the 75 s before and after closest approach, and the UV/VIS plus near-IR detectors will map the mineralogy.

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SOURCES SOUGHT FOR INNOVATIVE SCIENTIFIC INSTRUMENTATION FOR SCIENTIFIC LUNAR ROVERS. C. Meyer, Solar System Exploration Division, Mail Code SN2, NASA Johnson Space Center, Houston TX 77058, USA.

Lunar rovers should be designed as integrated scientific measurement systems that address scientific goals as their main objective. Scientific goals for lunar rovers are (1) to develop a more complete understanding of the stratigraphy, structure, composition, and evolution of the lunar crust by close examination of the geology and geochemistry of multiple, wide-spaced landing sites on the Moon; (2) to improve the understanding of the lunar regolith and history of solar system events that have affected the lunar surface; (3) to improve the understanding of the lunar interior and set constraints on planetary evolution using geophysical techniques; and (4) to identify and characterize potential lunar "resources" that could be utilized by future human missions.

Teleoperated robotic field geologists will allow the science team to make discoveries using a wide range of sensory data collected by electronic "eyes" and sophisticated scientific instrumentation. Rovers need to operate in geologically interesting terrain (rock outcrops) and to identify and closely examine interesting rock samples. Analytical instrumentation should measure the maturity of soils and the chemical composition (major, minor, and trace) and mineralogy of soils and fresh surfaces of rock samples. Some ingenious method is needed to obtain fresh rock surfaces. Manipulator arms are needed to deploy small close-up cameras and lightweight instruments, such as alpha backscatter spectrometers, as "stethoscopes" to the clasts in boulders. Geoscience missions should also deploy geophysical packages.

Enough flight-ready instruments are available to fly on the first mission, but additional instrument development based on emerging technology is desirable. There are many interesting places to explore on the Moon (i.e., the lunar poles) and it is highly desirable to fly multiple missions with continuously improved instrument sets. For example, there are needs for (1) *in situ* reflectance spectroscopy measurements (with high spectral resolution TBD) to determine the spectra (~0.3–2.5 μm) and mineral contents of rocks and soils in a manner analogous to what is done from a distance by Earth-based telescopes or from lunar orbit; (2) Mössbauer spectroscopy to determine soil maturity and mineralogy and relative abundance of iron-bearing phases; (3) close-up images by a "field-lens" electronic camera with artificial lighting and good depth focus (autofocus?) allowing scientists in the control room to have the ability to make discoveries and document what has been analyzed by the analytical instruments; (4) precise and accurate analytical measurements of the chemical composition of soils and rocks—especially the critical determination of the Fe/Mg ratio and one or more of the large ion lithophile elements; (5) cryogenic systems to cool solid-state detectors such as infrared sensitive CCD arrays, Si(Li) X-ray or Ge gamma ray detectors; (6) multispectral imagery by CCD cameras including telephoto, metric, or panoramic; (7) boresited laser range-finding equipment with gimbals that read out angles for precise site survey; and (8) thermally evolved gas analysis.

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DRILL/BORESCOPE SYSTEM FOR THE MARS POLAR PATHFINDER. D. A. Paige, S. E. Wood, and A. R. Vasavada, Department of Earth and Space Sciences, University of California, Los Angeles CA 90024, USA.

The primary goals of the Mars Polar Pathfinder (MPP) Discovery mission are to characterize the composition and structure of Mars' north polar ice cap, and to determine whether a climate record may be preserved in layers of ice and dust. The MPP would land as close as possible to the geographic north pole of Mars and use a set of instruments similar to those used by glaciologists to study polar ice caps on Earth: a radar sounder, a drill/borescope system, and a thermal probe. The drill/borescope system will drill ~50 cm into the surface and image the sides of the hole at 10-μm resolution for compositional and stratigraphic analysis.

Several uncertainties have guided the development of this instrument. It is presently not known whether the surface at the north pole consists of solid ice or packed snow, or how difficult it will be to drill. In order to more quantitatively investigate design and power requirements, we built a thermal chamber for testing the drill/borescope instruments under Mars-like conditions with complete remote control. To minimize the number of mechanisms and moving parts, an integrated drill/borescope system would be desirable for the MPP. However, for these initial tests we used separate off-the-shelf components: a Hilti model TE-10A rotary percussion drill, and an ITI 26-in rigid borescope attached to a Sony XC-999 cigar-type color CCD camera. The drill rotates at about 500 rpm while hammering at about 50 Hz, using about 150 W. Using a 1-in continuous-flute drill bit, it is able to drill through 12 in of –80°C solid ice in about two minutes, with no down-force applied except for its own weight. A talus pile of the low-density shavings forms around the surface, but the hole is left clear after the drill is retracted. The borescope is a hard-optics right-angled device with fiber-optic illumination at its tip. It is able to focus from near contact to infinity. The borescope has a 13° vertical field of view, which amounts to about 3 mm of vertical distance at the viewing distance in our 1-in-diameter holes. This equipment, and high-resolution vertical scans of two boreholes, are part of a videotape. We prepared three types of samples: pure ice, ice with dust layers, and snow with dust layers. To make the ice/dust sample we successively poured and froze a suspension of 2-μm cinder particles in water. The dust settles as the water freezes, and forms layers between clear ice. The first close-up images of the inside of a hole were taken in the solid ice/dust sample with the borescope as it is lowered slowly to the bottom. The ice in these images appears almost black, and the dust layers are reddish