unwanted background event. This arrangement has improved the energy resolution of proton lines, eliminated the need for an additional guard detector system, and substantially reduced the size of the sensor head.

However, the big saving in size and power in the APX instrument comes from replacing the cryogenically cooled Si or HP Ge X-ray detectors in the X-ray mode with HgI_2 ambient-temperature X-ray detectors that do not require cryogenic cooling to operate and still achieve high-energy resolution. These detectors are being provided by Xsirius, Inc. in Marina del Ray.

The spectrometer as it is implemented for Mars '94 and Mars '96 Russian missions (the Mars '94 and Mars '96 APX experiment are a collaboration of IKI of Moscow, The University of Chicago, and Max Planck Institut für Chemie in Mainz) and for NASA's Pathfinder mission (the APX experiment for Pathfinder will be a collaboration of MPI Mainz and The University of Chicago) to Mars in 1996 has a combined weight of about 600 g and operates on 250 mW of power. It still can benefit from higher-quality alpha sources available from the Russians and more hybridized electronics.

N93-28777 160723 p. 1

INVESTIGATION OF MARS ROTATIONAL DYNAMICS USING EARTH-BASED RADIO TRACKING OF MARS LANDERS. C. D. Edwards Jr., W. M. Folkner, R. D. Kahn, and R. A. Preston, Jet Propulsion Laboratory, California Institute of Technology, Pasadena CA 91109, USA.

The development of space geodetic techniques over the past two decades has made it possible to measure the rotational dynamics of the Earth at the milliarcsecond level, improving our geophysical models of the Earth's interior and the interactions between the solid Earth and its atmosphere. We have found that the rotational dynamics of Mars can be determined to nearly the same level of accuracy by acquiring Earth-based two-way radio tracking observations of three or more landers globally distributed on the surface of Mars (Fig. 1). Our results indicate that the precession and long-term obliquity changes of the Mars pole direction can be determined to an angular accuracy corresponding to about 15 cm/yr at the planet's surface. In addition, periodic nutations of the pole and seasonal variations in the spin rate of the planet can be determined to 10 cm or less. Measuring the rotation of Mars at this accuracy would greatly improve the determination of the planet's moment of inertia and would resolve the size of a planetary fluid core, providing a valuable constraint on Mars interior models. Detecting seasonal variations in the spin rate of Mars would provide global constraints on atmospheric angular momentum changes due to sublimation of the Mars CO_2 polar ice caps. Finally, observation of quasisecular changes in Mars obliquity would have significant implications for understanding long-term climatic change.

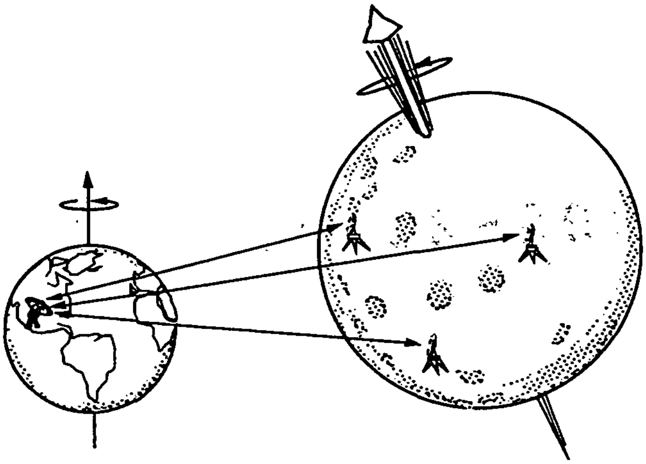

Fig. 1. Simultaneous two-way tracking of multiple Mars landers from Earth.

The key to achieving these accuracies is a globally distributed network of Mars landers with stable, phase-coherent radio transponders. By simultaneously acquiring coherent two-way carrier phase observations between a single Earth tracking station and multiple Mars landers, Earth media errors are essentially eliminated, providing an extremely sensitive measure of changes in the differential path lengths between the Earth tracking station and the Mars landers due to Mars rotation. Time variability of the instrumental phase delay through the radio transponder may represent the limiting error source for this technique. Calibration of the transponder stability to about 0.1 ns or less, over a single tracking arc of up to 12 hr, is sufficient to provide the decimeter-level determination of Mars orientation parameters quoted above.

We will provide a detailed description of the multilander tracking technique and the requirements it imposes on both the lander radio system and the Earth-based ground-tracking system. This concept is currently part of the strawman science plan for the Mars Environmental Survey (MESUR) mission and complements many of the other MESUR science goals.

N93-28778 160724 p-2

CLEMENTINE SENSOR PROCESSING SYSTEM. A. A. Feldstein, Innovative Concepts, Inc., 8200 Greensboro Drive, Suite 801, McLean VA 22102, USA.

The design of the DSPSE Satellite Controller (DSC) is baselined as a single-string satellite controller (no redundancy). The DSC performs two main functions: health and maintenance of the spacecraft, and image capture, storage, and playback. The DSC contains two processors, a radiation-hardened Mil-Std-1750, and a commercial R3000. The Mil-Std-1750 processor performs all housekeeping operations, while the R3000 is mainly used to perform the image processing functions associated with the navigation functions, as well as performing various experiments. The DSC also contains a data handling unit (DHU) used to interface to various spacecraft imaging sensors and to capture, compress, and store selected images onto the solid-state data recorder.

The development of the DSC evolved from several key requirements: The DSPSE satellite was to (1) have a radiation-hardened spacecraft control and be immune to single-event upsets (SEUs); (2) use an R3000-based processor to run the star tracker software that was developed by SDIO (due to schedule and cost constraints, there was no time to port the software to a radiation-hardened processor); and (3) fly a commercial processor to verify its suitability for use in a space environment.

In order to enhance the DSC reliability, the system was designed with multiple processing paths. These multiple processing paths provide for greater tolerance to various component failures. The DSC was designed so that all housekeeping processing functions are performed by either the Mil-Std-1750 processor or the R3000 processor. The image capture and storage is performed either by the DHU or the R3000 processor.

The DSC interfaces to six sensors using two data and control buses. The image data are compressed using a JPEG compression device. The DHU is configured on a frame-by-frame basis to either store data in an uncompressed form or store data in a compressed form using one of the four compression tables stored in the JPEG device. The captured images are stored in a 1.6-Gbit solid-state recorder that is part of the DSC for playback to the ground. Images can be captured by the DSC either on demand, one frame at a time, or by preloading a sequence of images to be captured by the DHU without processor or ground intervention.

As for the future, the Naval Research Laboratory is currently developing a fault-tolerant spacecraft controller using the RH3000 processor chip set. The processor includes shadow checker, real time hardware rollback, fault-tolerant memory, hardware cache coherence, and more.

S15 N93-28779 60725 p. 1

DESIGN CONCEPT FOR AN IR MAPPING SPECTROMETER FOR THE PLUTO FAST FLYBY MISSION.

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The design of an IR mapping spectrometer that exceeds all the criteria of the Pluto Fast Flyby Mission will be presented. The instrument has a mass of ~1700 g and uses less than 4 W of power. The design concept is based on an *f*/3 spectrograph using an aberration-corrected concave holographic grating. Up to four spectral regions can be covered simultaneously by dividing the grating into two to four sections, each imaging the entrance slit on a different area of the array. The spectrography will be fed by a lightweight 5" *f*/3 telescope based on SDIO precepts. In order to provide spectroscopic access to the fundamental molecule frequencies, an extended-range NICMOS array to ~3.5 μm and an InSb array going to 5.8 μm will be considered.

S16 N93-28780 60726 p. 1

MULTIBEAM LASER ALTIMETER FOR PLANETARY TOPOGRAPHIC MAPPING.

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Laser altimetry provides an active, high-resolution, high-accuracy method for measurement of planetary and asteroid surface topography. The basis of the measurement is the timing of the round-trip propagation of short-duration pulses of laser radiation between a spacecraft and the surface. Vertical, or elevation, resolution of the altimetry measurement is determined primarily by laser pulsewidth, surface-induced spreading in time of the reflected pulse, and the timing precision of the altimeter electronics. With conventional gain-switched pulses from solid-state lasers and nanosecond resolution timing electronics, submeter vertical range resolution is possible anywhere from orbital altitudes of ~1 km to altitudes of several hundred kilometers. Horizontal resolution is a function of laser beam footprint size at the surface and the spacing between successive laser pulses. Laser divergence angle and altimeter platform height above the surface determine the laser footprint size at the surface; while laser pulse repetition rate, laser transmitter beam configuration, and altimeter platform velocity determine the spacing between successive laser pulses.

Multiple laser transmitters in a single laser altimeter instrument that is orbiting above a planetary or asteroid surface could provide across-track as well as along-track coverage that can be used to construct a range image (i.e., topographic map) of the surface. We are developing a pushbroom laser altimeter instrument concept that utilizes a linear array of laser transmitters to provide contiguous across-track and along-track data. The laser technology is based on the emerging monolithic combination of individual, 1-cm^2 diode-pumped Nd:YAG laser pulse emitters. The laser pulse output at 1 μm that results from each element is approximately 1 ns in duration and is powerful enough to measure distance to the surface from short range (1–10 km). Laser pulse reception is accomplished in this concept by a single telescope that is staring at nadir and is equipped with a single detector element in its focal plane. This arrangement permits a fixed alignment of each transmitter output into a separate, dedicated sensor footprint, yet minimizes instrument complexity. For example, a linear array of 20 laser transmitters oriented perpendicular to the orbit motion could map an asteroid surface at a spatial resolution of 50 m in a 1-km swath. The two-dimensional topographic image might be most appropriate for missions in which multispectral imaging data are also acquired. The instrument is also capable of laser pulse energy measurement for each sensor footprint, yielding a measure of surface reflectance at the monochromatic 1-μm laser wavelength.

It should also be possible to produce a device that is capable of simultaneous operation on all elements for long-range operation at the millijoule-per-pulse performance level or time-division-multiplexed operation of single laser emitter elements to produce the desired pushbroom laser altimeter sensor pattern on the planetary or asteroid surface. Thus the same device could support operational ranging to an asteroid from long range and scientific observations at high resolution simply by simultaneously or sequentially addressing the multiple laser transmitter elements. Details of the multi-emitter laser transmitter technology, the instrument configuration, and performance calculations for a realistic Discovery-class mission will be presented.

S17 N93-28781 160727 p. 2

ACOUSTO-OPTIC INFRARED SPECTRAL IMAGER FOR PLUTO FAST FLYBY.

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Acousto-optic tunable filters (AOTFs) enable compact, two-dimensional imaging spectrometers with high spectral and spatial resolution and with no moving parts. Tellurium dioxide AOTFs operate from about 400 nm to nearly 5 μm, and a single device will