cameras and a polarization camera. For each set of input images, the innovators calculate degree of linear polarization (DOLP), back-project polarization pixels that have high DOLP into the left color image, generate a stereo range image (which is registered with the left color image), and insert detected mud into a world map using the stereo range data. As it is only expected for mud to occur on the ground surface, stereo range data are used to isolate ground surface pixels from the other pixels corresponding to ground clutter. Ground clutter pixels with high DOLP (such as vegetation) are ignored.

Techniques to estimate soil moisture content have been studied for decades for agricultural applications; however, mud detection for UGV autonomous navigation is a relatively new research area. Ground vehicle methods of soil moisture estimation have used passive microwave sensors, but the antennas tend to be bulky and have been mounted directly downwards. This requires a UGV to drive on potentially hazardous terrain in order to characterize it. This work involves de-

tecting mud hazards from a UGV without having to drive on the hazard first.

Mud detection is a terrestrial application; however, the intermediate image processing steps and world modeling techniques performed for this task are valuable to terrain hazard assessment in general, terrestrial, or planetary situations.

This work was done by Arturo L. Rankin and Larry H. Matthies of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-46624

Gas Flow Detection System

Commercial applications include flow measurement systems.

John F. Kennedy Space Center, Florida

This system provides a portable means to detect gas flow through a thin-walled tube without breaking into the tubing system. The flow detection system was specifically designed to detect flow through two parallel branches of a manifold with only one inlet and outlet, and is a means for verifying a space shuttle program requirement that saves time and reduces the risk of flight hardware damage compared to the current means of requirement verification.

The prototype Purge Vent and Drain Window Cavity Conditioning System (PVD WCCS) Flow Detection System consists of a heater and a temperature-sensing thermistor attached to a piece of Velcro to be attached to each branch of a WCCS manifold for the duration of the requirement verification test. The heaters and thermistors are connected to a shielded cable and then to an electronics enclosure, which contains the power supplies, relays, and circuit board to provide power, signal conditioning, and control. The electronics enclosure is then connected to a commercial data acquisition box to provide analog to

digital conversion as well as digital control. This data acquisition box is then connected to a commercial laptop running a custom application created using National Instruments' LabVIEW.

The operation of the PVD WCCS Flow Detection System consists of first attaching a heater/thermistor assembly to each of the two branches of one manifold while there is no flow through the manifold. Next, the software application running on the laptop is used to turn on the heaters and to monitor the manifold branch temperatures. When the system has reached thermal equilibrium, the software application's graphical user interface (GUI) will indicate that the branch temperatures are stable. The operator can then physically open the flow control valve to initiate the test flow of gaseous nitrogen (GN_2) through the manifold. Next, the software user interface will be monitored for stable temperature indications when the system is again at thermal equilibrium with the test flow of GN_2. The temperature drop of each branch from its "no flow" stable

temperature peak to its stable "with flow" temperature will allow the operator to determine whether a minimum level of flow exists.

An alternative operation has the operator turning on the software only long enough to record the ambient temperature of the tubing before turning on the heaters and initiating GN_2 flow. The stable temperature of the heated tubing with GN_2 flow is then compared with the ambient tubing temperature to determine if flow is present in each branch. To help quantify the level of flow in the manifolds, each branch will be bench calibrated to establish its thermal properties using the flow detection system and different flow rates. These calibration values can then be incorporated into the software application to provide more detailed flow rate information.

This work was done by Thomas Moss, Curtis Ihlefeld, and Barry Slack of Kennedy Space Center. For further information, contact the Kennedy Applied Physics Laboratory at (321) 867-7513. KSC-13174

Mapping Capacitive Coupling Among Pixels in a Sensor Array

Cross-talk calibration of all pixels can be performed efficiently.

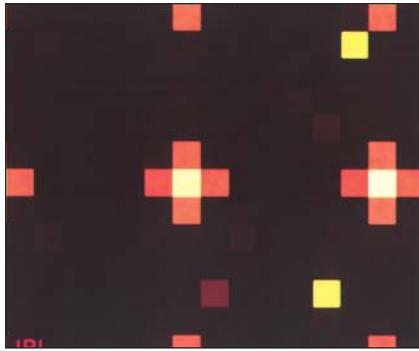*NASA's Jet Propulsion Laboratory, Pasadena, California*

An improved method of mapping the capacitive contribution to cross-talk among pixels in an imaging array of sensors (typically, an imaging photodetector array) has been devised for use in calibrating and/or

characterizing such an array. The method is applicable to almost all image detectors in modern electronic cameras for diverse applications, ranging from consumer cellular-telephone cameras at one extreme to

high-performance imaging scientific instruments at the other extreme. In comparison with prior methods of quantifying the capacitive coupling among pixels, this method is a more efficient means of ob-

taining detailed information pertaining to all the pixels. Unlike the prior methods, this method does not require flat-field illumination of the array: indeed, the method does not require any illumination.

The method involves a sequence of resets of subarrays of pixels to specified voltages and measurement of the voltage responses of neighboring non-reset pixels. The spacing of the reset pixels is chosen in accordance with the number of neighboring pixels over which the coupling coefficients are sought. The sequence begins with reset of all the pixels in the array to a specified first voltage level. In the next step, a subarray of pixels is reset to a specified second voltage level. Signals consisting of portions of the second reset voltage change are coupled capacitively from the pixels of the reset subarray to adjacent non-second-reset pixels. These signals can be mapped in the form of difference im-

This **Difference Image** from a portion of an image detector containing a rectangular pixel array was generated from two images: one recorded immediately after and one recorded immediately before the second reset. The second-reset pixels were those residing at intersections of rows and columns at seven-pixel intervals.

ages from the pixel voltages measured immediately before and immediately after the second reset (see figure). The

sequence as described thus far can be repeated for different subarrays of pixels, as needed, to acquire data for characterizing all pixels of interest. The entire sequence can be repeated to acquire multiple sets of data that can be combined to reduce measurement noise.

This work was done by Suresh Seshadri, David M. Cole, and Roger M. Smith of Caltech for NASA's Jet Propulsion Laboratory.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Fiber-Based Laser Transmitter for Oxygen A-Band Spectroscopy and Remote Sensing

Goddard Space Flight Center, Greenbelt, Maryland

A fiber-based laser transmitter has been designed for active remote-sensing spectroscopy. The transmitter uses a master-oscillator-power-amplifier (MOPA) configuration with a distributed feedback diode-laser master oscillator and an erbium-doped fiber amplifier. The output from the MOPA is frequency-doubled with a periodically poled nonlinear crystal. The utility of this single-frequency, wavelength-tunable, power-scalable laser has been demonstrated in a spectroscopic measurement of the diatomic oxygen A-band.

The problem that needed to be addressed was how to measure atmospheric state parameters (like temperature and pressure) from space to get local measurements and global coverage. The only successful laser transmitter that had been used for this type of measurement (remote sensing from an airplane) used dye and alexandrite lasers. These devices were both spectroscopically and mechanically unstable and very inefficient. This transmitter design offers many advantages over this technology.

Fiber-based technology vastly improves mechanical alignment issues because optical path is inside a waveguide that is spliced together and no longer contingent on the relative alignment of bulk optical parts. Many of the components are built to telecommunications industry reliability standards.

This work was done by Mark A. Stephen and James B. Abshire of Goddard Space Flight Center. For further information, contact the Goddard Innovative Partnerships Office at (301) 286-5810. GSC-15710-1

Low-Profile, Dual-Wavelength, Dual-Polarized Antenna

This antenna system has uses in remote monitoring of ocean storms and in search and rescue operations.

Goddard Space Flight Center, Greenbelt, Maryland

A single-aperture, low-profile antenna design has been developed that supports dual-polarization and simultaneous operation at two wavelengths. It realizes multiple beams in the elevation plane, and supports radiometric, radar, and conical scanning applications.

This antenna consists of multiple azimuth sticks, with each stick being a multilayer, hybrid design. Each stick forms the h-plane pattern of the C and Ku-band vertically and horizontally polarized antenna beams. By combining several azimuth sticks together, the ele-

vation beam is formed. With a separate transceiver for each stick, the transmit phase and amplitude of each stick can be controlled to synthesize a beam at a specific incidence angle and to realize a particular side-lobe pattern. By changing the transmit phase distribution