attenuator. To meet the compact size and maintain isolation between the channels, a two-sided module approach was adapted. The transmit side of the module houses the four transmit channels, the control FPGA, and the power regulators and logic circuitry. It also contains the 4-way stripline power splitter. The 4-dual channel receivers are packaged on the reverse side of the module along with the horizontal and vertical power combiners, and some logic and power conditioning circuits. The transmit and receive sides of the T/R module with the component identifications are shown in Figures 1 and 2.

The broadband, 4-channel, highly stable self calibrating T/R module is a useful building block for other radar and communication phased-array systems operating in this band.

This work was done by Constantine Andricos, Simon H. Yueh, Vladimir A. Krimskiy, of Caltech and Yahya Rahmat-Samii of UCLA for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-46428

Wide-Field-of-View, High-Resolution, Stereoscopic Imager

Lyndon B. Johnson Space Center, Houston, Texas

A device combines video feeds from multiple cameras to provide wide-field-of-view, high-resolution, stereoscopic video to the user. The prototype under development consists of two camera assemblies, one for each eye. One of these assemblies incorporates a mounting structure with multiple cameras attached at offset angles. The video signals from the cameras are fed to a central processing platform where each frame is color processed and mapped into a single contiguous wide-field-of-view image.

Because the resolution of most display devices is typically smaller than the processed map, a cropped portion of the video feed is output to the display device. The positioning of the cropped window will likely be controlled through the use of a head tracking device, allowing the user to turn his or her head side-to-side or up and down to view different portions of the captured image. There are multiple options for the display of the stereoscopic image. The use of head mounted displays is one likely implementation. However, the use of 3D projection technologies is another potential technology under consideration,

The technology can be adapted in a multitude of ways. The computing platform is scalable, such that the number, resolution, and sensitivity of the cameras can be leveraged to improve image resolution and field of view. Miniaturization efforts can be pursued to shrink the package down for better mobility. Power savings studies can be performed to enable unattended, remote sensing packages. Image compression and transmission technologies can be incorporated to enable an improved telepresence experience.

This work was done by Eric F. Prechtl of Axis Engineering Technologies, Inc., and Raymond J. Sedwick of the Massachusetts Institute of Technology for Johnson Space Center. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809.

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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Refer to MSC-23977-1, volume and number of this NASA Tech Briefs *issue, and the page number.*

Electrical Capacitance Volume Tomography With High-Contrast Dielectrics

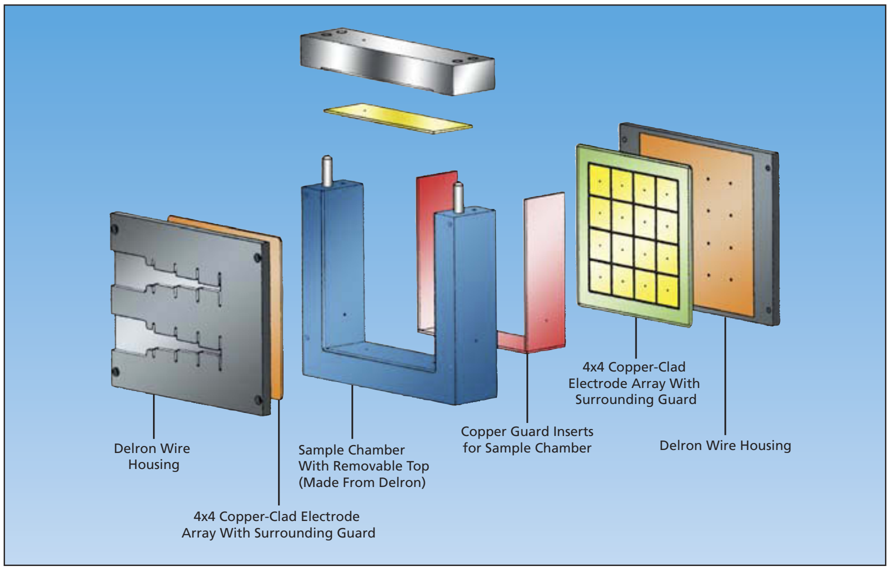
This nondestructive evaluation tool finds fluid levels in nonconducting composite materials.

John F. Kennedy Space Center, Florida

The Electrical Capacitance Volume Tomography (ECVT) system has been designed to complement the tools created to sense the presence of water in nonconductive spacecraft materials, by helping to not only find the approximate location of moisture but also its quantity and depth.

The ECVT system has been created for use with a new image reconstruction algorithm capable of imaging high-contrast dielectric distributions. Rather than relying solely on mutual capacitance readings as is done in traditional electrical capacitance tomography applications, this method reconstructs high-resolution images using only the self-capacitance measurements. The image reconstruction method assumes that the material under inspection consists of a binary dielectric distribution, with either a high relative dielectric value representing the water or a low dielectric value for the background material. By constraining the unknown dielectric material to one of two values, the inverse math problem that must be solved to generate the image is no longer ill-determined. The image resolution becomes limited only by the accuracy and resolution of the measurement circuitry. Images were reconstructed using this method with both synthetic and real data acquired using an aluminum structure inserted at different positions within the sensing region.

The cuboid geometry of the system has two parallel planes of 16 conductors arranged in a 4×4 pattern. The electrode geometry consists of parallel planes of copper conductors, connected through custom-built switch electronics, to a commercially available capacitance to digital converter. The figure shows



An exploded view of the **ECVT Sensor** shows the face of one of the two 4×4 arrays of conductors. Each sensing element is 1.9 cm on a side, placed on 2-cm centers, and separated from the opposing array by 3.3 cm.

two 4 × 4 arrays of electrodes milled from square sections of copper-clad circuitboard material and mounted on two pieces of glass-filled plastic backing, which were cut to approximately square shapes, 10 cm on a side. Each electrode is placed on 2.0-cm centers. The parallel arrays were mounted with the electrode arrays approximately 3 cm apart. The open ends were surrounded by a metal guard to reduce the sensitivity of the electrodes to outside interference and to help maintain the spacing between the arrays.

Other uses for this innovation potentially include quantifying the amount of commodity remaining in the fuel and oxidizer tanks while on-orbit without having to fire spacecraft engines. Another orbit application is moisture sensing in plant-growth experiments because microgravity causes moisture in soil to distribute itself in unusual ways.

At the moment, the hardware and image reconstruction technique may only be of interest to people involved in nondestructive evaluation. The reconstructed image takes almost a full week to reproduce with existing computer power. However, because computer power and speeds follows Moore's Law, execution times are likely to become acceptable within the next five to eight years. The code was written in Mathematica for dedicated use with the ECVT system. In its present form, it is not suitable to be used directly as a consumer product. However, the code could be likely improved by rewriting it in a compiled language such as C or Fortran.

This work was done by Mark Nurge of Kennedy Space Center. KSC-13038

Wavefront Control and Image Restoration With Less Computing

There are numerous potential applications in scientific, medical, and military imaging.

Goddard Space Flight Center, Greenbelt, Maryland

PseudoDiversity is a method of recovering the wavefront in a sparse- or segmented-aperture optical system typified by an interferometer or a telescope equipped with an adaptive primary mirror consisting of controllably slightly moveable segments. (PseudoDiversity should not be confused with a radio-antenna-arraying method called "pseudodiversity".) As in the cases of other wavefront-recovery methods, the streams of wavefront data generated by means of PseudoDiversity are used as feedback signals for controlling electromechanical actuators of the various segments so as to correct wavefront errors and thereby, for example, obtain a clearer, steadier image of a distant object in the presence of atmospheric turbulence. There are numerous potential applications in astronomy, remote sensing from aircraft and spacecraft, targeting missiles, sighting military targets, and medical imaging (including microscopy) through such intervening media as cells or water. In comparison with prior wavefront-recovery methods used in adaptive optics, PseudoDiversity involves considerably simpler equipment and procedures and less computation.

For PseudoDiversity, there is no need to install separate metrological equipment or to use any optomechanical components beyond those that are already parts of the optical system to which the method is applied. In PseudoDiversity, the actuators of a subset of the segments or subapertures are driven to make the segments dither in the piston, tilt, and tip degrees of freedom. Each aperture is dithered at a unique frequency at an amplitude of a half wavelength of light.

During the dithering, images on the focal plane are detected and digitized at a rate of at least four samples per dither period. In the processing of the image samples, the use of different dither frequencies makes it possible to determine the separate effects of the various dithered segments or apertures. The digitized image-detector outputs are processed in the spatial-frequency (Fourier-transform) domain to obtain measures of the piston, tip, and tilt errors over each segment or subaperture. Once these measures are known, they are fed back to the actuators to correct the errors. In addition, measures of errors that remain after correction by use of the actuators are further utilized in an algorithm in which the image is phase-corrected in the spatial-frequency domain and then transformed back to the spatial domain at each time step and summed with the images from all previous time steps to obtain a final image having a greater signal-to-noise ratio (and, hence, a visual quality) higher than would otherwise be attainable.

This work was done by Richard G. Lyon of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15464-1