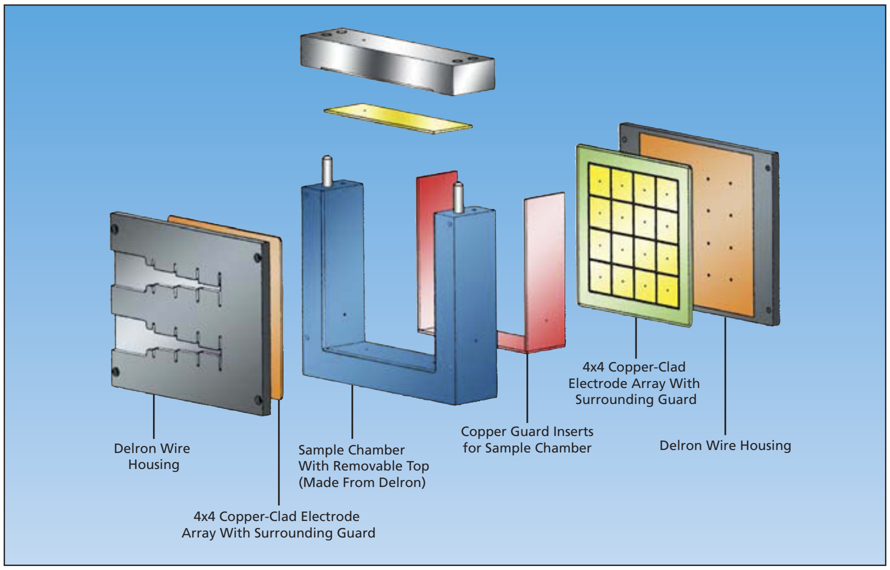

An exploded view of the **ECVT Sensor** shows the face of one of the two 4×4 arrays of conductors. Each sensing element is 1.9 cm on a side, placed on 2-cm centers, and separated from the opposing array by 3.3 cm.

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