flowing water, consisted mainly in the encapsulation of the fibers in a tube of Tygon polyvinyl chloride (PVC) with an inside diameter of 1 in. (≈25 mm). In operation, water is pumped along the insides of the hollow fibers and oxygen gas is supplied to the space outside the hollow tubes inside the PVC tube.

In tests, the pressure drops of water and oxygen in the module were found to be close to zero at water-flow rates ranging up to 320 mL/min and oxygen-flow rates up to 27 mL/min. Under all test conditions, no bubbles were observed at the water outlet. In some tests, flow rates were chosen to obtain dissolved-oxygen concentrations between 25 and 31 parts per million (ppm) — approaching the saturation level of ≈35 ppm at a temperature of 20 °C and pressure of 1 atm (≈0.1 MPa).

As one would expect, it was observed that the time needed to bring a flow of water from an initial low dissolved-oxygen concentration (e.g., 5 ppm) to a steady high dissolved-oxygen concentration at or near the saturation level depends on the rates of flow of both oxygen and water, among other things. Figure 2 shows the results of an experiment in which a greater flow of oxygen was used during the first few tens of minutes to bring the concentration up to ≈25 ppm, then a lesser flow was used to maintain the concentration.

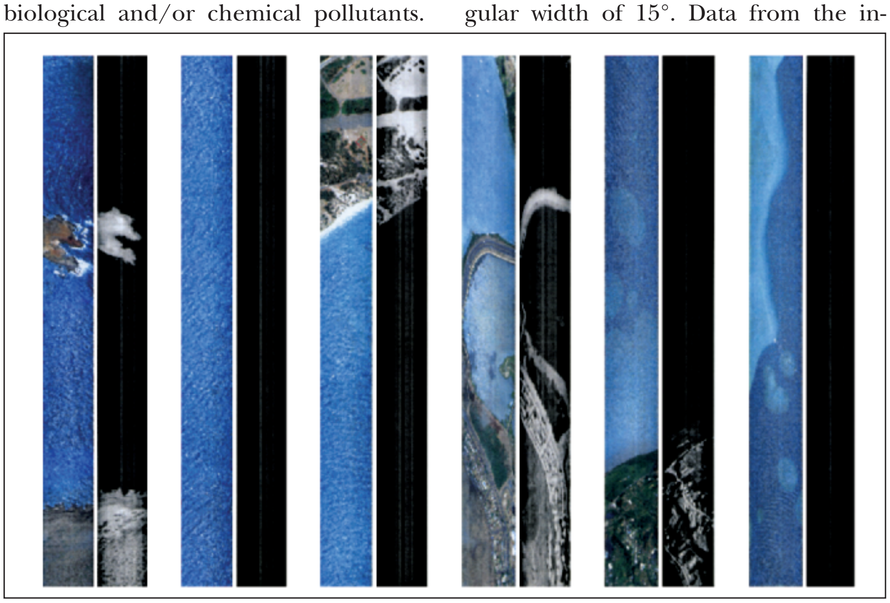
This work was done by Anuncia Gonzalez-Martin , Reyimjan Sidik, and Jinseong Kim of Lynntech, Inc., for **Johnson Space Center**. *For further information, contact the Johnson Commercial Technology Office at (281) 483-3809.*
MSC-23138

Coastal Research Imaging Spectrometer

Color and temperature images yield information on contents and sources of flows.

Stennis Space Center, Mississippi

The Coastal Research Imaging Spectrometer (CRIS) is an airborne remote-sensing system designed specifically for research on the physical, chemical, and biological characteristics of coastal waters. The CRIS includes a visible-light hyperspectral imaging subsystem for measuring the color of water, which contains information on the biota, sediment, and nutrient contents of the water. The CRIS also includes an infrared imaging subsystem, which provides information on the temperature of the water. The combination of measurements enables investigation of biological effects of both natural and artificial flows of water from land into the ocean, including diffuse and point-source flows that may contain biological and/or chemical pollutants. Temperature is an important element of such measurements because temperature contrasts can often be used to distinguish among flows from different sources: for example, a sewage outflow could manifest itself in spectral images as a local high-temperature anomaly.



These **Color and Monochrome Images** of the same ocean areas were generated from outputs of the visible-light hyperspectral and infrared subsystem, respectively, of the CRIS during its test flight.

Both the visible and infrared subsystems scan in "pushbroom" mode: that is, an aircraft carrying the system moves along a ground track, the system is aimed downward, and image data are acquired in across-track linear arrays of pixels. Both subsystems operate at a frame rate of 30 Hz. The infrared and visible-light optics are adjusted so that both subsystems are aimed at the same moving swath, which has across-track angular width of 15°. Data from the infrared and visible imaging subsystems are stored in the same file along with aircraft-position data acquired by a Global Positioning System receiver. The combination of the three sets of data is used to construct infrared and hyperspectral maps of scanned areas (see figure).

The visible subsystem is based on a grating spectrograph and a rapid-readout charge-coupled-device camera. Images of the swatch are acquired in 256 spectral bands at wavelengths from 400 to 800 nm. The infrared subsystem, which is sensitive in a single wavelength band of 8 to 10 μm, is based on a focal-plane array of HgCdTe photodetectors that are cooled to an operating temperature of 77 K by use of a closed-Stirling-cycle mechanical cooler.

The nonuniformities of the HgCdTe photodetector array are small enough that the raw pixel data from the infrared subsystem can be used to recognize temperature differences on the order of 1 °C. By use of a built-in blackbody calibration source that can be switched into the field of view, one can obtain bias and gain offset terms for individual pixels, making it possible to offset the effects of nonuniformities sufficiently to enable the measurement of temperature differences as small as 0.1 °C.

This work was done by Paul G. Lucey, Timothy Williams, and Keith A. Horton of Pacific Island Technology, Inc., for **Stennis Space Center**.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Intellectual Property Manager, Stennis Space Center, (228) 688-1929.
Refer to SSC-00158