thin films of materials with a conductive grid or striped pattern. The conductive pattern may be applied by several methods, including printing, plating, sputtering, photolithography, and etching, and can include as many detection layers that are necessary for the structure construction or to afford the detection detail level required. The damage is detected using a detector or sensory system, which may include a time domain reflectometer, resistivity monitoring hardware, or other resistance-based systems.

To begin, a layered composite consisting of thin-film damage detection layers separated by non-damage detection layers is fabricated. The damage detection layers are attached to a detector that provides details regarding the physical health of each detection layer individually. If damage occurs to any of the detection layers, a change in the electrical properties of the detection layers damaged occurs, and a response is generated. Real-time analysis of these responses will provide details regarding the depth, location, and size estimation of the damage. Multiple damages can be detected, and the extent (depth) of the damage can be used to generate prognostic information related to the expected lifetime of the layered composite system.

The detection system can be fabricated very easily using off-the-shelf equipment, and the detection algorithms can be written and updated (as needed) to provide the level of detail needed based on the system being monitored. Connecting to the thin film detection layers is very easy as well. The truly unique feature of the system is its flexibility; the system can be designed to gather as much (or as little) information as the end user feels necessary. Individual detection layers can be turned on or off as necessary, and algorithms can be used to optimize performance. The system can be used to generate both diagnostic and prognostic information related to the health of layer composite structures, which will be essential if such systems are utilized for space exploration. The technology is also applicable to other in-situ health monitoring systems for structure integrity.

This work was done by Martha Williams, Mark Lewis, and Luke Roberson of Kennedy Space Center; and Pedro Medelius, Tracy Gibson, Steven Parks, and Sarah Snyder of ASRC Aerospace Corporation. For further information, contact the KSC Technology Transfer Office at (321) 867-5033. Refer to KSC-13588.

ULTRA: Underwater Localization for Transit and Reconnaissance Autonomy

NASA's Jet Propulsion Laboratory, Pasadena, California

This software addresses the issue of underwater localization of unmanned vehicles and the inherent drift in their onboard sensors. The software gives a 2 to 3 factor of improvement over the state-of-the-art underwater localization algorithms.

The software determines the localization (position, heading) of an AUV (autonomous underwater vehicle) in environments where there is no GPS signal. It accomplishes this using only the commanded position, onboard gyros/accelerometers, and the bathymetry of the bottom provided by an onboard sonar system. The software does not rely on an onboard bathymetry dataset, but instead incrementally determines the position of the AUV while mapping the bottom.

In order to enable long-distance underwater navigation by AUVs, a localization method called ULTRA uses registration of the bathymetry data products produced by the onboard forward-looking sonar system for hazard avoidance during a transit to derive the motion and pose of the AUV in order to correct the DR (dead reckoning) estimates. The registration algorithm uses iterative point matching (IPM) combined with surface interpolation of the Iterative Closest Point (ICP) algorithm. This method was used previously at JPL for onboard unmanned ground vehicle localization, and has been optimized for efficient computational and memory use.

This work was done by Terrance L. Huntsberger of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

This software is available for commercial licensing. Please contact Dan Broderick at Daniel.F.Broderick@jpl.nasa.gov. Refer to NPO-48559.

Autonomous Cryogenic Leak Detector for Improving Launch Site Operations

Virtually all storage tanks of hydrogen and other flammable gases could use this sensor technology.

John F. Kennedy Space Center, Florida

NASA, military, and commercial satellite users need launch services that are highly reliable, less complex, easier to test, and cost effective. This project has developed a tapered optical fiber sensor for detecting hydrogen. The invention involves incorporating chemical indicators on the tapered end of an optical fiber using organically modified silicate nanomaterials.

The Hazardous Gas Detection Lab (HGDL) at Kennedy Space Center is involved in the design and development of instrumentation that can detect and qualify various mission-critical chemicals. Historically, hydrogen, helium, nitrogen, oxygen, and argon are the first five gases of HGDL focus. The use of these cryogenic fluids in the area of propulsion offers challenges. Due to their extreme low temperatures, these fluids induce contraction of the materials they contact, a potential cause of leakage. Among them, hydrogen is of particular concern.

Small sensors are needed in multiple locations without adding to the structural weight. The most vulnerable parts of the engine are the connection flanges on the transfer lines, which have to support cycles of large thermal amplitude. The thermal protection of the engine provides a closed area, increasing the likelihood of an explosive atmosphere. Thus, even a small leak represents an unacceptable hazardous condition during loading operations, in flight, or after an aborted launch.

Tapered fibers were first fabricated from 1/1.3-mm core/cladding (silica/plastic) optical fibers. Typically a 1-ft (≈30-cm) section of the 1-mm fiber is cut from the bundle and marked with a pen into five 2-¼-in. (≈5.7-cm) sections. A propane torch is applied at every alternate mark to burn the jacket and soften the glass core. While the core is softening, the two ends of the fiber are pulled apart slowly to create fine tapers of ¼- to ½-in. (≈6- to 12-mm) long on the 1-mm optical fiber. Following this, the non-tapered ends of the fibers are polished to a 0.3-micron finish. Then these fibers were coated with indicators sensitive to hydrogen.

The tapered hydrogen detection system with its unique flexibility is the only system that can be placed in many locations inside the vehicles and detect the exact location of leaks, saving millions of dollars for launch vehicle industries.

This work was done by Kisholoy Goswami of Innosense LLC for Kennedy Space Center. Further information is contained in a TSP (see page 1). KSC-13436

Submillimeter Planetary Atmospheric Chemistry Exploration Sounder

NASA's Jet Propulsion Laboratory, Pasadena, California

A report describes the Submillimeter Planetary Atmospheric Chemistry Exploration Sounder (SPACES), a high-sensitivity laboratory breadboard for a spectrometer targeted at orbital planetary atmospheric analysis. The frequency range is 520 to 590 GHz, with a target noise temperature sensitivity of 2,500 K for detecting water, sulfur compounds, carbon compounds, and other atmospheric constituents. SPACES is a prototype for a powerful tool for the exploration of the chemistry and dynamics of any planetary atmosphere. It is fundamentally a single-pixel receiver for spectral signals emitted by the relevant constituents, intended to be fed by a fixed or movable telescope/antenna. Its front-end sensor translates the received signal down to the 100-MHz range where it can be digitized and the data transferred to a spectrum analyzer for processing, spectrum generation, and accumulation.

The individual microwave and submillimeter wave components (mixers, LO high-powered amplifiers, and multipliers) of SPACES were developed in cooperation with other programs, although with this type of instrument in mind. Compared to previous planetary and Earth science instruments, its broad bandwidth (≈13%) and rapid tunability (≈10 ms) are new developments only made possible recently by the advancement in submillimeter circuit design and processing at JPL.

This work was done by Erich T. Schlecht, Mark A. Allen, John J. Gill, Choonsup Lee, Robert H. Lin, Seth Sin, Imran Mehdi, and Peter H. Siegel of Caltech; and Alain Maestrini of the Observatoire de Paris for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48207