

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 dam-

age 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) in-

formation 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.*

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## **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](mailto:Daniel.F.Broderick@jpl.nasa.gov). Refer to NPO-48559.*

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## **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 in-

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