being developed to utilize the information and provide input on the residual strength of the structure, and maintain a history of structural degradation during usage. The structural health-monitoring system would consist of three major components: (1) sensors and a sensor network, which is permanently bonded onto the structure being monitored; (2) integrated hardware; and (3) software to monitor *in-situ* the health condition of in-service structures.

This work was done by Xinlin P. Qing, Christopher Aquino, and Amrita Kumar of Acellent Technologies, Inc. for Glenn Research Center.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18396-1.

A Safe, Self-Calibrating, Wireless System for Measuring Volume of Any Fuel at Non-Horizontal Orientation

This system can be used for any fluid, including cryogenic and caustic liquids.

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A system for wirelessly measuring the volume of fluid in tanks at non-horizontal orientation is predicated upon two technologies developed at Langley Research Center. The first is a magnetic field response recorder that powers and interrogates magnetic field response sensors ["Magnetic Field Response Measurement Acquisition System," (LAR-16908), *NASA Tech Briefs*, Vol. 30, No. 6 (June 2006), page 28]. Magnetic field response sensors are a class of sensors that are powered via oscillating magnetic fields and when electrically active respond with their own magnetic fields whose attributes are dependent upon the magnitude of the physical quantity being measured. The response recorder facilitates the use of the second technology, which is a magnetic field response fluid-level sensor ["Wireless Fluid-Level Sensors for Harsh Environments," (LAR-17155), *NASA Tech Briefs*, Vol. 33, No. 4 (April 2009), page 30].

The method for powering and interrogating the sensors allows them to be completely encased in materials (Fig. 1) that are chemically resilient to the fluid being measured, thereby facilitating measurement of substances (e.g., acids, petroleum, cryogenic, caustic, and the like) that would normally destroy electronic circuitry. When the sensors are encapsulated, no fluid (or fluid vapor) is exposed to any electrical component of the measurement system. There is no direct electrical line from the vehicle or plant power into a fuel container. The means of interrogating and powering the sensors can be completely physically and electrically isolated from the fuel and vapors by placing the sensor on the other side of an electrically non-conductive bulkhead (Fig. 2). These features prevent the interrogation system and its electrical components from becoming an ignition source.

Measuring fuel volume while the tank is not level would benefit aircraft during uncoordinated roll and pitch maneuvers, boat fuel tanks in heavy waves, and trucks, trains, and automobiles moving on steep inclines. The system can be used for any fluid, including cryogenic and caustic liquids. If the geometry of the tank is known, the surface defining the liquid/air interface can be determined by measuring the frequency re-

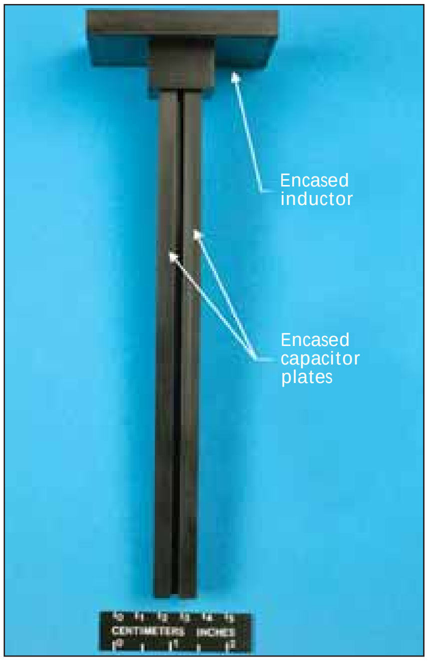

Figure 1. **Magnetic Field Response Fluid-Level Sensor** completely encapsulated in Ertalyte PET-P plastic.

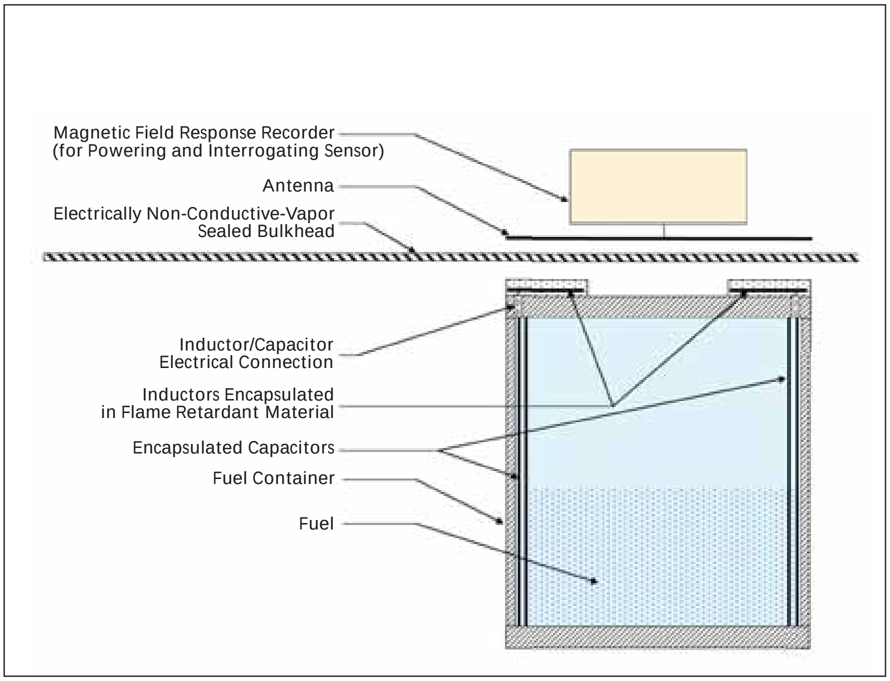

Figure 2. **Fuel Tank With Encapsulated Sensors** outboard bulkhead. Magnetic field response recorder and antenna are on other side of bulkhead.

sponse from at least three sensors in contact with the liquid. When internal baffles are used, the surface is that of a plane with fluid perturbations about the plane. When successive fuel-level readings are acquired and averaged, the results will approximate that of a plane. Once this surface is known, it can be used with the tank geometry to determine the volume under the surface.

Solely capacitive sensors are directly connected to power source and interrogation equipment. They must be calibrated for all capacitance in the sensor and the electrical wires to the sensor, making it necessary to have the sensor electronics near or at the probe because lead length affects the capacitance of the probe. The magnetic field response sensor system presented provides an added logistical advantage in that electrical leads do not affect their calibration. Each sensor can easily be calibrated by taking the response frequency when the tank is empty, then again when the tank is full. One can then easily determine the sensor response with respect to the fractional fluid level without the need for additional measurements, and therefore know the fractional level (e.g., 0.1 full) without knowing the fluid dielectric, sensor material, sensor geometry, or tank geometry. With the advent of vehicle engines using many different types of fuels with each having a different dielectric, it is advantageous for a measurement system that can easily be calibrated for any fluid without having to take the vehicle to a maintenance facility.

This work was done by Stanley E. Woodard of Langley Research Center and Bryant D. Taylor of ATK Space Division. Further information is contained in a TSP *(see page 1)***.**
LAR-17116-1